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BOTANY.

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THE
GENERAL GENTEE
PRECEPTOR:

PART THE FOURTH.

BEING

A SUMMARY INTRODUCTION TO

B O T A N Y.

ADAPTED TO THE SERVICE AND INSTRUCTION OF

YOUTH OF BOTH SEXES;

AND OTHERS,

WHO WISH TO ACQUIRE, OR TO CONFIRM, USEFUL AND PLEASING
KNOWLEDGE IN THE VARIOUS BRANCHES OF

E D U C A T I O N.

BY

FRANCIS FITZGERALD, ESQ.

ADORNED AND ILLUSTRATED BY SIXTEEN PLATES.

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THE
GENERAL GENTEEL PRECEPTOR.

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P A R T IV.

BEING AN
INTRODUCTION

TO THE STUDY OF
B O T A N Y.

.....
P A R T I.

.....
AN INTRODUCTORY DISCOURSE ON THE GENERAL
PRINCIPLES OF VEGETATION.

THE lower we descend in the scale of life, the greater is our embarrassment, arising from numbers and varieties of species. If we find it necessary to content ourselves with general ideas, and with a selection only of fish and of insects, difficulties still greater, prevent our intimate knowledge of vegetables, whose innumerable kinds, though long the study of naturalists, are daily proving that many remain unknown and unnoticed. Nor is this surprising, when we recollect the different situations, soils, and exposures, which they prefer; the different levels at which they grow, on plains or on mountains, in dales or on alps: every spot producing some peculiar to itself. Being adapted to extremes of heat and cold, of humidity and dryness, to every climate, to every region, they are infinitely various: and

Part IV. No. 23.

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however

however human industry may have explored, with assiduous toil, not only inhabited countries but inhospitable wilds, yet, after all endeavours, many kinds will elude research, though perhaps native at no great distance, or perhaps their season lately past, or soon to come.

Declining, therefore, to enter deeply into a subject which has furnished many a bulky and expensive folio, and whose nomenclature alone, when skilfully arranged and abridged, forms solid volumes, we shall offer those leading principles, which being of general use, may be brought to the test of daily experience: for assuredly that learning seems most advantageous, whose usefulness and application is perpetually recurring; that which is most simple, which is ever at hand, and ever delightful, is well worthy our attention, and most strongly claims our acquaintance; without depreciating what may possess occasional usefulness or pleasure, what may delight or profit on emergency.

If pleasure be requested by mankind,—the purest pleasure is furnished by the tribes of vegetables, and human talents seem peculiarly adapted to their culture and enjoyment: If profit be requested,—these sustain life, by furnishing food in various forms and of various qualities; they restore health, and counteract disease, they regale the senses by their beauty and colours, by their odour and fragrance, by their relish and poignancy: they raise the mind to cheerfulness, by delightful combination in the elegant parterre; they dispose it to solemnity, by the deep umbrage of the majestic grove. When the bending corn waves in golden ridges, courting the sickle; when the luxuriant vine, wedded to its sturdy elm, hangs in purple festoons, from bough to bough, every heart beats in grateful joy. O were men but sensible of real glory and true honour, they would seek it, not on the ensanguined, but on the cultivated plain; not in spreading destruction, but in diffusing life through various ranks; they “would beat their swords into plough-shares, and their spears into pruning-hooks.”

Mankind, exposed to inclement seasons, will ever be beholden to vegetables for shelter; hence our obligations to timber-trees

trees of all sorts, from the stately oak, of which ships are constructed, to the slender osier, which yields only wattles. But by fruit-bearing trees, we are doubly accommodated, not only with shelter but with food; not only with wood, but with provision; hence the apple, pear, plum, peach, cherry, and many others, are highly valuable; they furnish our tables with a dessert, and delight our palates with their relish: and if the vine boast no wood for beams and for furniture, its noble fruit is, temperately used, invaluable. All nations have had recourse, for cheering drinks, to infusions, or to the sap of vegetables.

Grain is a part of provision, on which we depend with assurance; whose absence nothing can supply; whose loss nothing can compensate. Happily, it is not only fertile and productive, but its nutritive qualities are not impaired by many years of keeping.

Garden vegetables unite delicacy of taste to salubrity; they offer us choice of roots or plants, of pulse or herbs; some for present use, others for stores.

The beaten fibres of the hemp yield elegance and health: the hardy stalks furnish our ships with wings. The most immense sail is but an union of hempen threads; the strongest cable is but a combination of twists, weak asunder, but whose united strength resists the rolling waves, ensuring security to the adventurous mariner, amid the swellings of the mighty deep.

It is worth our while to obtain some general knowledge of the properties of plants, as we can never foresee under what circumstances we may be obliged to them for assistance; or to what farther uses a judgment of their properties from first sight, or from casual acquaintance, may lead us.

Smell and taste give some intimation of the nature and qualities of plants. An agreeable taste or smell is seldom accompanied with noxious qualities; but, when these senses are disagreeably affected by plants, their qualities are generally more or less noxious, being purgative, emetic, or poisonous. Plants

of a sweet taste, are generally nutritive; those of a salt taste, are warm and stimulant. Plants of an acrid taste, are corrosive; but, when deprived of their acrimony by drying, some of them become fit for food. Bitter plants are alkaline, stomachic, and sometimes of a suspicious nature. Acid plants are cooling, and allay thirst; but those of an austere taste are astringent.

The colour and aspect of plants throw some light upon their nature. Flowers or fruit of a red colour, are generally acid. Yellow flowers indicate a bitter taste. Plants that have green flowers, are crude; those of a pale colour, commonly insipid; those of a white colour, generally sweet; and those whose flowers have a gloomy and dismal aspect, are mostly poisonous.

We shall first attend to the leading principles whereby nature produces those effects which delight or surprise us, and then we shall apply those principles of art which are found necessary in order to procure some kind of regularity amidst such numerous tribes as the vegetable kingdom presents to our notice.

In continuing this discourse, we propose to treat separately,

1. On the generation or propagation of vegetables.
2. On their growth and nourishment.
3. On their structure.

When we have offered some general remarks on these subjects, we shall be prepared to attend, with advantage, to the more accurate investigations of the Botanist.

ON THE GENERATION OR PROPAGATION
OF VEGETABLES.

Vegetables are capable of Propagation,

- (1.) By Slips or Cuttings committed to the Earth.
- (2.) By Grafts inserted on Trees of a different Kind.
- (3.) By Seeds.

(1.) VEGETABLES are capable of propagation by slips and cuttings; and, perhaps, far beyond what is related of any animal whatever, wonderful as are the facts admitted of the Polypus; but, whether there be any vegetable capable of propagation only by this method, is not, that I know of, affirmed; or, whether there be any vegetable entirely precluded from this method: for not only plants may, by trailing, be made to shoot from the knots, &c. in their stems, but branches of trees, if judiciously managed, will become complete trees, not inferior in magnitude to their parents; nor are the sub-divisions of vitality in the fruit of a potatoe less remarkable—every *eye* is capable of producing a perfect plant. There is, however, one singularity attending vegetables, *i.e.* that as the branches are capable of becoming roots, so the roots are capable of becoming branches. Should we incline to change the situation of these parts of a tree, the undertaking is feasible, and has been accomplished in smaller subjects, by surrounding the branches with earth in a garden-pot; and, when they have drawn nutriment from the earth, gradually withdrawing the root from its bed, and accustoming it to depend for supply on its former branches; then judiciously choosing the time for its exposure to the air, and its production of leaves.

(2.) Grafting is a kind of planting of a branch from one tree on the body of another; to this it unites, with this it lives and prospers, or withers and decays: but it does not here unite by shooting out roots as it would do were it in the earth, for its nutritive juices are not to seek; the tree supplies them, partly digested too, and fit for use. This is clearly the case, where trees of a similar nature are united, and where curiosity has combined dissimilar natures, it has been partly the case; the nutriment has been in some degree advanced toward fitness, and the graft has completed its deficiency. That juices thus twice *strained*, as it were, first by the roots of the tree, then by the pores of the graft, should gain or lose somewhat alterative to the
flavour

flavour of the fruit yielded by the graft, is not wonderful; that it should be enriched or mellowed, should be acidulated or softened, seems natural, and to depend in great measure on the qualities of the tree from which it now derives its nourishment.

(3.) But as the general propagation of vegetables is rather by seeds than by any other mode, to them we shall now direct our attention.

SEEDS of plants are of various figures and sizes. Most are divided into two globes; though some (as those of the cress-kind) have six; and others (as the grains of corn) are entire.

But as the essential properties of all seeds are the same, when considered with regard to the principles of vegetation, our description shall be limited to the great garden-bean: because, after it begins to vegetate, its parts are more conspicuous than many others, and consequently better calculated for investigation.

This seed is covered with two coats or membranes; the outer extremely thin and full of pores, but may be easily separated from the inner one (which is much thicker) after the bean has been boiled, or lain a few days in the soil. At the thick end of the bean is a small hole visible to the naked eye, immediately over the radicle or future root, that it may have a free passage into the soil. When those coats are taken off, the body of the seed appears, which is divided into two smooth portions or lobes. The smoothness of the lobes is owing to a thin film or cuticle with which they are covered. At the basis of the bean is placed the radicle or future root, whose trunk, just as it enters into the body of the seed, divides into two capital branches, one to each lobe, and sends off smaller ones in all directions through the whole substance of the lobes: these become so extremely minute toward the edges of the lobes, that they require the finest glasses to render them visible. This GREW and MALPHIGIUS named the *seminal root*; because, by means of this, the radicle and plume, before they are expanded, derive their principal nourishment.

The plume, bud, or germ, is enclosed in two small corresponding cavities in each lobe. Its colour and consistence is much the same with those of the radicle, of which it is only a continuation; but having a quite contrary direction: for the radicle descends into the earth, and divides into a great number of branches and filaments; but the plume ascends into the air, and unfolds itself into stem, branches, leaves, flowers, fruit, &c. The plume in corn, shoots from the smaller end of the grain.

The substance, or parenchymatous part of the lobes is not a mere concreted juice, but is curiously organized, and consists

of a vast number of small bladders, resembling those in the pith of trees.

In assimilating the animal and vegetable kingdoms, LINNÆUS denominates seeds, the eggs of plants. The fecundity of plants is marvellous: a single stalk of Indian or Turkey wheat, produced, in one summer, 2000 seeds; elecampane, 3000; sun-flower, 4000; poppy, 32,000; a spike of cat's-tail, 10,000; a single fruit, or seed-vessel of tobacco, contains 1000 seeds; of white poppy, 8000. Mr. RAY relates, from experiments made by himself, that 1012 tobacco-seeds weigh one grain; and that the weight of all the seeds in a single tobacco-plant, according to the above proportion, determines their number to be 360,000. The same author estimates the annual produce of a single stalk of spleen-wort to be upwards of one million of seeds.

The dissemination of plants respects the different methods, or vehicles, by which Nature has contrived to disperse their seeds for the purpose of increase. These, by naturalists, are generally reckoned four:

I. Rivers and running waters.

II. The wind.

III. Animals.

IV. An elastic spring, peculiar to the seeds themselves.

Seeds which are carried along by rivers and torrents, are frequently conveyed many hundreds of leagues from their native soil, and cast on very different climates, to which, however, by degrees, they become familiar.

Those carried by the wind, are either winged, furnished with a *pappus*, or downy crown; placed within a winged calix, or seed-vessel; or, contained within a swelled calix, or seed-vessel.

Many birds swallow the seeds of vanello, juniper, mistletoe, oats, millet, and other grasses, and void them entire. Squirrels, rats, parrots, and other animals, suffer many of the seeds which they devour to escape, and thus in effect disseminate them. Moles, ants, earth-worms, and other insects, by ploughing up the earth, admit a free passage to those seeds which have been scattered upon its surface.

Some seeds attach themselves to animals, by means of hooks, crotchets, or hairs, which are either affixed to the seeds themselves, to their calix, or to their fruit, or seed-vessel.

Seeds, which disperse themselves by an elastic force, have that force resident either in their calix, as in oats, and the greater number of ferns; in their *pappus*, as in *centaurea crupina*; or in their capsule, as in geranium, horse-tail, cucumber, &c.

GROWTH

GROWTH OF PLANTS.

WHEN the seed is sown, a nutritive moisture is first absorbed by the outer coats; which are every where furnished with sap and air-vessels; by these it is conveyed to the cuticle; the cuticle transmits it to the pulpy part of the lobes, where it enters the mouths of the small branches of the seminal root, and passes from one branch to another into the main trunk, which communicates with the plume and radicle: then this vegetable food runs in two opposite directions; part *ascending* into the plume, promotes its growth and expansion; part *descending* into the radicle, nourishes the root and its filaments. Thus a plant is really possessed of two roots, both contained in the seed. The plume and radicle, when the seed is first deposited in the earth, derive their nourishment from the seminal root; afterwards, when the radicle begins to shoot out its filaments, and to absorb some moisture (not, however, sufficient to supply the wants of the plume) the two lobes, or main body of the seed, rise with the plume, assume the appearance of two leaves, resembling the lobes of the seed in size and shape, but having no resemblance to those of the plume, for which reason they have been called *dissimilar leaves*.

These *dissimilar leaves* defend the young plume from injuries, and at the same time, by absorbing dew, air, &c. assist the tender radicle in nourishing the plume, with which they still are connected by means of the seminal root. But, when the radicle has descended deep enough into the earth, and has acquired a sufficient number of filaments for absorbing so much aliment as the growth of the plume demands, then the (seminal or) *dissimilar leaves*, their utility being superseded, begin to decay, and gradually fall off.

Thus, as an egg contains not merely the foetus of an animal, but a portion of suitable nourishment, whereby it is sustained, for a considerable time; so a seed contains a portion of food fitted to nourish the nascent root, capable of becoming part of it, and of supporting it till its own powers are competent to that purpose; from which period, the plant is to derive a supply from the root, by means of its ramifications, and their absorbent properties.

The different species of seeds are longer or shorter in rising, according to the degree of heat which is proper for each. Millet, wheat, and several of the grasses, rise in one day; spinach, bean, mustard, and others, in three days; lettuce and dill, in four; cucumber, melon, and cress, in five; radish and beet, in six; barley, in seven; orach, in eight; purslane, in nine; cabbage,
in

in ten; hyssop, in thirty; parsley, in forty or fifty days; peach, almond, and others, in one year; rose-bush, hawthorn, and hazel-nut, in two. The seeds of some species of orchis, and of some liliaceous plants, never rise at all. Of seeds, some require to be sowed almost as soon as they are ripe; otherwise they will not sprout or germinate. Others, particularly those of the peabloom flowers, preserve their germinating faculty for a series of years.—Mr. Adanson asserts, that the sensitive plant retains that virtue for thirty or forty years.

Air and water are the agents of germination. The humidity of the air makes several seeds to rise. Seeds too are observed to rise in water, without earth: but water, without air, is insufficient.

For want of air, seeds buried very deep in the earth, either thrive but indifferently, or do not rise at all.

They frequently preserve, however, their germinating virtue for many years, within the bowels of the earth; and it is not unusual, upon a piece of ground newly dug to a considerable depth, to observe it soon after covered with several plants, which had not been seen there in the memory of man.

Some seeds require a greater quantity of air than others. Thus purslane, which does not rise till after lettuce in the free air, rises before it in vacuo; and both prosper but little, or perish altogether, while cresses vegetate as freely as in the open air.

The vessels in the roots of plants absorb moisture from the earth; and from the root it is conveyed to the trunk, branches, leaves, &c. This moisture, when it first enters the root, is crude; but as it ascends in the plant, it undergoes several changes, by means of the different configurations of the vessels peculiar to each part. For the leaves, flowers, fruit, and seed, have each something peculiar in the structure and arrangement of their vessels, which produces answerable changes in the nature of the sap. It is not known how these changes are produced: but how the stomachs of animals make chyle from animal and vegetable substances, or how urine, saliva, bile, &c. are secreted from the common mass of blood, is as little known. The sap likewise spreads laterally as well as rises perpendicularly.

The vegetable juices or fluids are generally reduced to two: the lymph or sap; and the blood or proper juice. It appears, however, that plants contain many other fluids; for in a single fruit, such as a pine-apple, orange, or strawberry, we can distinguish by the taste and smell three or four other liquors, of which we can discover but very feeble vestiges in the other parts of these plants.

The sap, or lymph, is a simple fluid, without colour or smell, and little different from water. It may be compared to the chyle in the animal œconomy, as may the roots which absorb and prepare it, to the lacteals. It is purified, as the blood of animals, by perspiration.

Philosophers were greatly divided about the circulation of the sap: some contending, that it returns to the root between the bark and wood. But HALE, who made many accurate experiments, suggests, that it does not circulate, but ascends and descends in the same vessels; that it ascends in hot weather, and descends in cold, like the spirits in a thermometer.

That the sap or lymph ascends from the root to the stem, branches, leaves, and even the minutest parts of the fructification, is past a doubt. But whether the sap so diffused to the extremities of the plant returns; and whether there be in plants a circulation of sap, analogous to that of the blood in animals, is a question which will probably never receive a satisfactory answer; as the data required for its solution are exceedingly numerous, and almost without our reach.

Vegetables begin to absorb sap early in spring, and soon after shoot their buds, leaves, and flowers.

In spring, the sap is found in the greatest abundance, and then the bark is easily detached from the wood. On the contrary, when the sap-season is past, the bark is found closely applied, and, as it were, glued to the wood. The leaves contribute greatly both to the abundance and motion of the sap. If a tree, when high in sap, is divested of its leaves, the bark, in a few days, will adhere as closely to the wood as in winter.

Plants in a state of vegetation, especially in hot weather absorb much superfluous sap; but the superfluity is carried off by transpiration: Every part of a plant transpires, but the greater quantity passes by the leaves.

Some have assigned the transpiration of plants as the cause of the motion of the sap: it is undoubtedly one cause, for, if transpiration be stopped at a time when the vessels are full, the motion of the sap must stop of course. But then there is a previous and principal cause, whatever it is, that first puts the sap in motion before transpiration has commenced.

Heat, moisture, and air, are the three chief circumstances that promote the ascent of the sap. Hence, nothing is more favourable to vegetation than warm weather, accompanied with rain; on the other hand, cold dry weather is its greatest enemy. In a wet cold season every thing rots; in hot dry weather every thing is parched: but the circumstances most favourable to vegetation are cloudy hot weather, inclinable to thunder, succeeded by plentiful rains.

The

The other sort of fluid contained in plants, is denominated the proper juice, and is analogous to the blood in animals. It is a compound liquor, and is easily distinguished, by its colour, smell, and substance, from the lymph or sap.

This fluid is either green, as in periwinkle; white, as in spurge, fig-tree, and dog's-bane; yellow, as in celandine; red, as in log-wood, and dragon's-blood; mucilaginous, or gummy, as in the jujube and mallow-tribes; or resinous, as in the cone-bearing plants. It is from this variety in colour and substance, that the liquor in question is called the proper juice; each species of plant being supposed to contain a fluid which is proper and peculiar to it.

In this blood, or proper juice, reside the smell, taste, and virtue of the plants.

The blood, or proper juice, is contained in tubes, which are larger than the lymphatic or sap-vessels, and although diffused through the whole substance of the plant, are collected in greater abundance in the bark. In fir-trees, the turpentine, which is the proper juice, is amassed in the parenchymatous substance, immediately under the epidermis or skin of the bark: in juniper, the sandarac is collected betwixt the bark and the wood: in the larch-tree, the turpentine which it produces is accumulated in the body of the wood; in pine, it exudes from the bark, from betwixt the wood and bark, from the wood itself, and from the pith.

It would appear very improbable, that the same matter could nourish such numerous families of plants, differing so essentially in smell, taste, figure, &c. Much, however, may be explained by considering the great variety apparent in the internal structure and arrangement of the vessels. If the vessels in any plant be uncommonly small, particles will be rejected by that plant, which would be absorbed by one of larger vessels. Nay, changes may be made in the crude homogeneous nourishment, by a small difference in the figure or action of the vessels.

One plant will starve another, by robbing it of nourishment; either by extending its roots, and requiring a greater quantity of nourishment, or by absorbing the peculiar food which is necessary for the growth of the other plant.

That a poisonous plant and its antidote will grow in the same soil, may be owing either to these plants imbibing different juices from the earth, or to their peculiarities in the structure and action of their vessels.

A stalk of lemon, grafted on a branch of an orange-tree, grew, ripened its fruit, and preserved the figure, and all the other qualities belonging to a lemon. This plainly indicates, that the organization of the lemon gave a different modifica-

tion to the juices of the orange, through whose intervention received nourishment.

It is also certain, that different parts of the same plant have various smells, tastes &c. although the nourishment derived from the root must be the same. Hence it appears, that the different structure of parts in the same plant is capable of producing sensible changes in the nature and quality of the sap.

Repeated experiments show, that many plants of opposite qualities, and even trees, have been nourished and brought to maturity by water alone.

The roots of plants are fitted to absorb every fluid that comes within their reach. They have been found by experiment to imbibe fluids that actually poison them, whence it may be fairly concluded, that they have not, like animals, the sagacity of choosing the food that is most proper for them.

That the earth may supply a variety of juices and even of contrary qualities, is undeniable; that a plant may have pores too narrow to admit some is also undeniable: but it seems to me that somewhat also must be attributed to that kind of juice to which a plant has been accustomed; for we know that if a number of worsted threads be hung in a basin of oil, so that they absorb the oil, and it run through them, they will not in like manner imbibe water; the oil they contain forbids it; if they are squeezed never so dry, so that apparently the oil were expelled from them, yet what little remains will unfit those threads for the absorption of water: the same occurs if they had been imbued with water, they will refuse to transmit oil. May we not then suppose that one effect of the pulpy part of the seed has been to accustom the fibres of the seminal root to such a juice as suits its nature? or have not those fibres drawn from (perhaps through) that pulp a juice tinged or contaminated with its own properties, and thereby partly concocted for the aliment of the plants? to which being habituated and thoroughly drenched in it, it ever after admits passage to those only which are of a similar nature. Thus a poisonous seed accustoms its offspring-fibres to a poisonous juice, and perpetuates their properties. In an earth which does not furnish such a juice; the plant will not thrive, if it will live; which perhaps it *may*, by assimilating such innocent juices as it procures, so far as it can, to its own nature, which yet may not be far enough to perfect its properties; whence that may be deadly in one soil which in another is only noxious, or that noxious in one which in another is only insipid; and with this seems to agree the analogy of most vegetable poisons, which often by transplantation lose their most lively properties; also the variation of plants, corn, &c. which in one soil flourish, perhaps improve, in another degenerate; this cause then traces their

their properties to their origin, and shows the nature impressed upon them; which probably is preserved by a greater or less number of each plant respectively always occupying a portion of earth, where it meets with juices adapted to its maintenance in full vigour. It is natural, that after having passed through a number of canals and passages from the root to the branches (and perhaps acquiring a tinge from many in its progress) it should be highly impregnated ere it arrive at the fruit; where, and especially in the seeds of that fruit, it should undergo the last stage of exaltation, and be ripened into qualities perfectly corresponding to those of the tree.

That plants partake of the nature of the soil whereon they grow is notorious; and this in no trifling degree: plants which in a free soil have no nitre in them, yet yield nitre when they grow on a nitrous soil, as is often experienced in the nitre-works in France: nay the very kind of manure used in the cultivation has been thought to influence the taste of vegetables.

Though I have said plants *may* live by assimilating such juices as they *can* procure, yet I apprehend if there be an absolute dearth of such as are proper to them, though there be plenty of others in the spot where they grow, they will pine, languish and die. Hence water-plants cannot support a dry soil, and heath-plants are rotted by humidity. Nevertheless, it is asserted, that as the desert plains of Africa, where a parched and sandy soil prohibits vegetation, yield only mosses and lichens, so the highest Alpine regions, and the most rigorous northern climates, yield only mosses and lichens also. Strange that the same plants should support extremes of heat and cold, yet refuse to flourish in temperate climates and on richer soils!

STRUCTURE OF PLANTS.

We shall present our information on this subject in the following order:

1. Of the ROOT.
2. The TRUNK.
3. The LEAVES.
4. FLOWERS.
5. FRUITS.

We now proceed to notice the STRUCTURE of plants: and first of the root.

In examining the ROOT of plants, the first thing that presents itself is the skin, which is of various colours in different plants. Every root after it has arrived at a certain age, has a double skin. The first, or epidermis, is coeval with the other parts,
and

and exists in the feed; afterwards a ring sent off from the bark forms a second skin; *e. g.* in the root of the *Dandelion*, towards the latter end of May, the original or outer skin appears shrivelled, and is easily separated from the new one, which is fresher and adheres more firmly to the bark. Perennial plants are supplied with a new skin every year; the outer one falls off in the autumn or winter, and a new one is formed from the bark in the succeeding spring. The skin has numerous cells or vessels, and is a continuation of the parenchymatous part of the radicle. However, it does not consist solely of parenchyma, for the microscope shows that there are many tubular ligneous vessels interspersed through it.

The organization and internal structure of the different parts of vegetables, such as the stems and branches, the leaves, the calix, the petals, and seeds, is not exactly the same; in some they are formed of two or three; in others of all the simple organical parts contained in the bark and wood of the stem, in which the organization is most apparent.

When the skin is removed, the true cortical substance or **BARK** appears, which is also a continuation of the parenchymatous part of the radicle, but greatly augmented. The bark is of very different sizes. In most trees it is exceedingly thin in proportion to the wood and pith. On the other hand, in *carrots*, it is almost one half of the semidiameter of the root; and in *dandelion* it is nearly twice as thick as the woody part.

The **ROOT BARK** is composed of different substances, the parenchyma, or pulp, which is the principal part, and woody fibres. The parenchyma is exceedingly porous, and has great resemblance to a sponge; it shrivels considerably when dried, and dilates to its former dimensions when steeped in water. These vessels do not communicate with each other, but consist of distinct little cells or bladders, scarcely visible without a microscope. In all roots, these cells are constantly filled with a thin watry liquor. They are generally spherical, though some, as the *bugloss* and *dandelion*, are oblong. In many roots, as the *horse-radish*, *peony*, *asparagus*, *potato*, &c. the parenchyma, is of one uniform structure; but in others it is more diversified, and assumes the appearance of rays diverging from the centre to the circumference of the bark. These rays sometimes run quite through the bark, as in *lovage*; and sometimes advance toward the middle of it, as in *meliot* and most of the leguminous and umbelliferous plants. They generally stand equally distant from each other in the same plant; but the distance varies greatly in different plants. Neither are they of equal sizes: in carrot they are exceedingly small, and scarcely discernable; in *meliot* and *chervil* they are thicker. They are likewise more numerous in some plants

plants than in others. Some are of uncommon thickness from one edge of the bark to the other; some grow wider as they approach the skin. The vessels with which these rays abound are supposed to be air-vessels, because they are found dry, and not so transparent as the vessels which evidently contain the sap.

All roots have ligneous vessels dispersed in different proportions through the parenchyma of the bark. These run longitudinally through the bark, in the form of long threads, tubular, as is evident from the rising of the sap in them when a root is cut transversely. These ligneous sap-vessels at small distances incline to one another in such a manner, that they appear to the eye to be inosculated; but the microscope discovers them to be only contiguous, and braced together by the parenchyma. These braces are various in size and number in different roots; but in all plants are most numerous toward the inner edge of the bark: like the nerves in animals, they are bundles of twenty or thirty small contiguous cylindrical tubes, which run from the extremity of the root, without sending off any branches, or suffering any change in size or shape.

In some roots (as parsnips) the ring of these vessels next the inner extremity of the bark contains a kind of lymph sweeter than the sap in the bladders of the parenchyma: from this circumstance they have got the name of *lymph-ducts*. These lymph-ducts sometimes yield a mucilaginous lymph, as in the comphrey; and sometimes a white milky glutinous lymph, as in the angelica, fenchus, burdock, scorfonera, dandelion, &c. The lymph-ducts are supposed to be the vessels which secrete the gums and balsams. The lymph of fennel exposed to the air, becomes a clear transparent balsam; that of the scorzonera, dandelion, &c. condenses into a gum.

The situation of the vessels is various. In some plants they stand in a ring or circle at the inner edge of the bark, as in asparagus; in others they appear in lines or rays, as in borage; in the parsnip, and several other plants, they are most conspicuous towards the outer edge of the bark; in the dandelion they are disposed in the form of concentric circles.

The wood of roots is that part which appears after the bark is taken off, and is firmer and less porous than the bark. It consists of two distinct substances: (1) the pulpy or parenchymatous; (2) the ligneous. The wood is connected to the bark by large portions of the bark inserted into it, mostly in the form of rays, tending to the centre of the pith, easily discernible in a transverse section of most roots. These insertions, like the bark, consist of many vessels, mostly round or oval.

The ligneous vessels are generally disposed in collateral rows running longitudinally through the root. Some of these contain

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air, others sap. The air-vessels are distinguished by being whiter.

The PITH is the central part of the root. Some roots have no pith, as the stramonium, nicotiana, &c.; others have little or none at the extremities of the roots, but a considerable quantity near the top. The pith, like every other part of the plant, is derived from the seed: but in some it is more immediately derived from the bark; for the insertions of the bark running in betwixt the rays of the wood, meet in the centre, and constitute the pith. It is owing to this circumstance, that certain roots which have no pith in the lower part, are amply provided with it towards the tops, as columbine, lovage, &c.

The bladders of the pith are of different sizes, generally of a circular figure. Their position is more uniform than in the bark. Their sides are a composition of small fibres or threads, which gives the pith, when viewed with a microscope, the appearance of a piece of fine gauze or net-work.

We shall conclude the description of roots with observing, that their whole substance is nothing but a congeries of tubes and fibres adapted by nature for the absorption of nourishment.

OF THE TRUNK.

In describing the trunks of plants, we observe, that whatever is said of them applies equally to the branches.

The TRUNK, like the root, consist of three parts; the bark, wood, and pith. These, though substantially the same in the trunk as in the root, are often very different in texture and appearance.

1. The skin of the bark is composed of very minute bladders, interspersed with longitudinal woody fibres, as in the nettle, thistle, and most herbs. The outside of the skin is visibly porous in some plants, particularly the cane.

The principle body of the bark is composed of pulp or parenchyma, and innumerable vessels, much larger than those of the skin. The texture of the pulp, though the same substance with the parenchyma in roots, seldom exhibits rays running towards the pith; and when these rays do appear, they seldom extend above half way to the circumference. The vessels of the bark are differently situated, and destined for different purposes, in different plants. In the bark of the pine, the inmost are lymphducts, exceedingly small; the outermost are gum or resiniferous vessels, destined for the secretion of turpentine; and are so large as to be distinctly visible to the naked eye.

2. The WOOD lies between the bark and pith, and consists of two parts; (1) parenchymatous, (2) ligneous. In all trees,
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the parenchymatous part of the wood, though diversified as to size and consistence, is uniformly disposed in diametrical rays, or insertions running between similar rays of the ligneous part.

The true wood is a congeries of old dried lymph-ducts. Between the bark and the wood a new ring of these is formed every year, which gradually loses its softness as the cold season approaches, and about the middle of winter is condensed into a solid ring of wood. These annual rings, which are distinctly visible in most trees when cut through, serve as natural marks to distinguish their age. The rings of one year are sometimes larger, sometimes less, than those of another, probably owing to the favourableness or unfavourableness of the season wherein they were formed.

The pith, though of a different texture, is exactly of the same substance with the parenchyma of the bark, and the insertions of the wood. The quantity of pith is various in different plants. Instead of being increased every year like the wood, it is annually diminished, its vessels drying up and assuming the appearance and structure of wood: insomuch that in old trees there is scarcely such a thing as pith to be found.

A ring of sap-vessels is usually placed at the outer edge of the pith, next the wood. In the pine, fig, and walnut, they are very large. The parenchyma of the pith is composed of small cells or bladders, of the same kind with those of the bark, but larger. The general figure of these bladders is circular; though in some plants, as the thistle and borage, they are angular. Though the pith is originally one connected chain of bladders, yet as the plant grows old, it shrivels and opens in different directions. In the walnut, after a certain age, it appears in the form of a regular transverse hollow division. In some plants it is altogether wanting; while in others, as the sonchus, nettle, &c. there is only a transverse partition of it at every joint. Many other varieties might be mentioned.

OF LEAVES.

THE LEAVES of plants consist of the same substance with the trunk. They are full of woody portions, running in all directions, and branching out into innumerable small threads (interwoven with the parenchyma) like fine lace or gauze.

The skin of the leaf is full of pores, which serve for perspiration, for the absorption of dews, air, &c. These pores differ in shape and magnitude in different plants, whence originates their variety of texture or grain. The pulpy or parenchymatous part consists of very minute fibres, wound up into small cells or bladders. These cells are of various sizes in the

same leaf. All leaves, of whatever figure, have a marginal fibre, by which the whole is bounded. The particular shape of this fibre determines the figure of the leaf. The vessels of leaves have the appearance of inosculating; but, when examined by the microscope, they are found only to be interwoven, or laid along each other. What are called air-vessels, or those which contain no sap, are visible even to the naked eye in some leaves. When a leaf is slowly broken, they appear like small woolly fibres, connected to both ends of the broken piece.

OF FLOWERS.

The texture, vessels, &c. of FLOWERS, are pretty similar to those of the leaf. Every flower is perfectly formed many months before it appears outwardly; that is, the flowers which appear this year, are not, properly speaking, flowers of this year, but of the last. For example, mezerion generally flowers in January; but these flowers were completely formed in the month of August preceding. By separating the coats of a tulip-root, about the beginning of September, we find that the two innermost form a kind of cell, in the centre of which stands the young flower, which is not to make its appearance till the following April, or May.

OF FRUITS.

IN describing the structure of FRUITS, a few examples shall be taken from such as are most generally known.

A PEAR, besides (1.) the skin, which is a production of the skin of the bark, consists of (2.) a double parenchyma or pulp, (3.) sap-vessels, (4.) air-vessels, (5.) a *calculary*, (6.) an *acetary*.

The *outer* parenchyma is the same substance, continued from the bark, only its bladders are larger and more succulent. It is every where interspersed with small globules or grains, and the bladders respect these grains as a kind of centre; every grain being the centre of a number of bladders. The sap and air-vessels in this pulp are extremely small.

Next the core is the *inner pulp*, or parenchyma, which consists of bladders of the same kind with the outer, only larger and more oblong, corresponding to those of the pulp, from which it seems to be derived. This inner pulp is much sourer than the other, and has none of the small grains interspersed through it, and hence it is named the *acetary*.

Between the *acetary* and outer pulp, the globules or grains begin to grow larger, and gradually unite into a hard stony body, especially towards the *corculum*, or heart of the fruit; and from
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this circumstance it has been called the *calculary*. These grains are not derived from any of the organical parts of the tree, but seem rather to be a kind of concretion precipitated from the sap, similar to the precipitations from wine, urine, and other liquors.

The core (*cœur*) is a roundish cavity in the centre of the pear, lined with a hard woody membrane, inclosing the seed. At the bottom of the core is a small duct or canal, which runs up to the top of the pear; this canal allows the air to enter the core for the purpose of drying and ripening the seeds.

In a LEMON, the parenchyma or pulp appears in three different forms. The parenchyma of the rind is of a coarse texture, composed of thick fibres, woven into large bladders: those nearest the surface contain the essential oil of the fruit, which kindles into flame when the skin is squeezed over a candle. This outer parenchyma furnishes nine or ten insertions of thin plates or *lamellæ*, each inclosing a portion of the pulp, and all uniting into one body in the centre of the fruit, which corresponds to the pith in the trunk or roots. At the bottom and top of the lemon, this pith evidently joins the rind, without the intervention of any *lamellæ*. This circumstance shows that the pith and bark are actually connected in the trunk and roots of plants, though it is difficult to demonstrate the connection, on account of the closeness of their texture, and the minuteness of their fibres. Many vessels are dispersed through the whole of this pulp; but the larger stand on the inner edge of the rind and the outer edge of the pith, just at the two extremities of each lamella.

The second kind of pulp or parenchyma is placed between the rind and the pith, is divided into distinct bodies by the *lamellæ*; and each of these bodies forms a large bag. These bags contain a third parenchyma, which is a cluster of smaller bags, distinct and unconnected, having small stalks by which they are fixed to the large bag. Within each of these small bags are many hundreds of bladders, composed of extremely minute fibres. These contain the acid juice of the lemon.

These instances may suffice to show the general nature and structure of the fruit-vessels: we shall now proceed to notice a subject of the greatest curiosity in the vegetable world, the irritability of plants.

THE IRRITABILITY OF PLANTS.

THE irritability of plants is a curious subject; but not yet entirely elucidated. It is not always alike, but capable of increase and decrease; is said to be greatest in the morning, less at noon, still less in the evening; greatest in spring, less in summer, still less in autumn: whether it be recruited by winter torpidity, therefore most abundant in spring; or by nightly repose, therefore most abundant in the morning; or whether it may not depend on the different states of the atmosphere, which in spring and morning is humid and cool, is questioned. That humidity is grateful to plants, is clear; that coolness constricts their fibres, as heat renders them flaccid, loose, and therefore probably inert, by reason of a smaller degree of tension, is also clear. Whether this latter cause may not influence those plants which apparently follow the sun, has been doubted; for if those parts of the stem whereon his rays fall most immediately are thereby rendered weaker than those not exposed to his rays, doubtless they will give way, and the flower will bend to that side. If this be true, and also that coolness constricts the fibres of plants, then that such constriction should act principally on those parts which had been expanded, *i. e.* the flower, is natural. That coolness obtains before rain, and in the evening, is certain; and on this principle the closure of certain plants and flowers is accounted for; but as some are opening and closing at all times (inasmuch that *Linnaeus*, by observing their state informs us we may know the hour of the day, and hence calls them *Flora's Watch*), and as others open only during night, this cause seems inadequate to such great variety of effects. What is termed the sleep of plants, is supposed to proceed from exhaustion of irritability, and is most observable in young plants, and in spring.

The *Mimosa* or *Sensitive Plant* (of which *Linnaeus* reckons forty-six species) is the great instance of irritability; as beside contracting its leaves in the evening, it may be made to contract them at any time, by the touch of the hand, the fumes of volatile alkali, must, opium, or the electric spark: and this contraction is so powerful, that on its taking place, the leaves may be easier broken than re-expanded; but the plant will regain its natural state after an interval of from ten minutes to half an hour. Immersion in water does not produce these effects. Their general progress is according to the force or quantum of stimulus engaged on the plant, affecting first one leaf, then its fellow or pair on the stalk, then the pedicle or foot-stalk, moving upwards, then all the leaves on that branch to the very stem of the plant.

plant. A shaking motion affects the whole plant ; but it is impossible to affect the branches and not the leaves.

The Sensitive and Humble plants are arranged by Linnaeus under the same genus with the acacias.

The sensibility of these plants is lodged in the young branches, in the common foot-stalk of the winged leaves, and in the nerve or middle rib to which the lobes or lesser leaves are attached. The different motions, which seem to be totally independent of each other, may be aptly enough compared, by analogy, with the irritability of certain parts in animals.

The sensitive plant has two kinds of motion ; the one natural, occasioned by the action of warm nourishing vapours ; the other artificial, in consequence of being touched or shaken.

Mr. Duhamel having observed, about the fifteenth of September, in moderate weather, the natural motion of a branch of a sensitive plant, remarked that at nine in the morning it formed with the stem an angle of one hundred degrees ; at noon, one hundred and twelve degrees ; at three in the afternoon, it returned to one hundred ; and after touching the branch, the angle was reduced to ninety. Three quarters of an hour after, it had mounted to one hundred and twelve ; and at eight at night, it descended again, without being touched, to ninety.

The day after, in finer weather, the same branch, at eight in the morning, made an angle of one hundred and thirty-five degrees with the stem ; after being touched, the angle was diminished to eighty ; an hour after, it arose again to one hundred and thirty-five ; being touched a second time, it descended again to eighty ; an hour and a half after, it had risen to one hundred and forty-five ; and upon being touched a third time, descended to one hundred and thirty five, and remained in that position till five in the afternoon ; when being touched a fourth time, it fell to one hundred and ten.

With whatever body the sensitive plant is touched or irritated, it is remarkable that the sensibility resides particularly in the articulation or joining either of the branches of the common footstalk, or of the particular foot-stalk of each wing.

The time which a branch requires to recover itself after being touched, varies according to the vigour of the plant, the hour of the day, the season of the year, or the heat, and other circumstances of the atmosphere.

The order in which the parts recover themselves, varies in like manner ; sometimes it is the common foot-stalk ; sometimes the rib to which the lobes are attached ; and sometimes the lobes themselves are expanded, before the other parts have made any attempt to be re-inflated in their former position.

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If, without shaking the other smaller leaves, we cut off the half of a lobe belonging to the last pair, at the extremity or summit of a wing, the leaf cut, and its antagonist, that is to say, the first pair, begin to approach each other; then the second; and so on successively, till all the lesser leaves or lobes of that wing have collapsed in like manner. Frequently, after twelve or fifteen seconds, the lobes of the other wings, which were not immediately affected by the stroke, shut; while the stalk and its wing, beginning at the bottom, and proceeding in order to the top, gradually recover themselves.

If instead of one of the lesser extreme leaves, we cut off one belonging to the pair that is next the foot-stalk, its antagonist shuts, as do the other pairs successively, from the bottom to the top.

If all the lobes of one side of a wing be cut off, the opposite lobes are not affected, but remain expanded.

With some address, it is possible even to cut off a branch, without hurting the leaves or making them fall.

The common foot-stalk of the winged leaves being cut as far as three fourths of its diameter, all the parts which hang down collapse; but quickly recover, without appearing to have suffered any considerable violence by the shock.

An incision being made into one of the principal branches, to the depth of one half of the diameter, the branches situated betwixt the section and the root will fall down: those above the incision remain as before, and the lesser leaves continue open; but this direction is soon destroyed, by cutting off one of the lobes at the extremity, as was observed above.

Lastly a whole wing being cut off, with precaution, near its insertion into the common foot-stalk, the other wings are not affected by it, and its own lobes do not shut. No motion likewise ensues from piercing the branch with a needle or other sharp instrument.

Different from all the kinds of sensitive plants hitherto known, is the *dionæa muscipula*, or Venus's fly-trap, a plant discovered in the swamps of North America, and now cultivated in the gardens of Europe. The plant is of very low growth, and rises with a naked stalk; it is garnished at the bottom with eight or nine simple leaves with winged foot-stalks, which proceed immediately from the root. In the figure and sensibility of these leaves, consists the oddity of the plant. Each leaf is almost round, but furnished at its margin, with a set of long teeth or feelers not unlike the antennæ or horns of many insects. This leaf, as I said, runs out into a foot-stalk, which is not of equal breadth throughout, but enlarges towards the top. Upon touching the leaves in cold weather, no sensible contraction ensues; in warm weather,

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and particularly at noon, it is very strong. But what is most remarkable of this plant is, its rare way of destroying flies and other insects which approach it. A fly no sooner touches the upper surface of the leaf, than the two lobes approach, and crush the insect to death; the teeth or feelers at the margin, no doubt, contributing to hasten that event.

The cause of this and the other motions of plants is merely external. The motions themselves, therefore, are not spontaneous, as in perfect animals, which have that cause dependant on their choice and will.

The negroes in Senegal call a large species of sensitive plant, which grows in that country, *guerackino*; that is, good-morrow; because, say they, when you touch it, or draw near to speak to it, the plant immediately inclines its leaves, to wish you, as it were, a good-morrow, and to show that it is sensible of the politeness done it. In the same country is produced a small sensitive plant, that is rampant, not spinous, and which Mr. Adanson affirms to be infinitely more delicate and sensible than all the other species.

That plants are greatly affected by the impulse of light, appears from the instance of this plant. A sensitive plant, placed in a dark cave, was twenty-four hours before it expanded, and then very partially; suffered no change at night or morning: but being placed in the open air, it recovered its natural state and irritability. Another kept in a dark room during some hours after day-break, did not expand; but, being restored to the light, expanded without delay.

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Parasitical plants, which grow on other trees, as the mistletoe, or which climb on other trees, as the ivy, and numberless others, are a curious class of plants; many of which never drew nourishment from mother earth, but from their supporting tree, which they often strangle and destroy. In hot countries these are sometimes so noxiously abundant, that no art can exterminate them.

Vegetables are greatly exposed to the depredations of insects: almost every plant has numbers attached to it, and many suffer by several in succession; while just sprouting, being the favourite food of some; when further advanced, of others; and when mature, of others.

Vegetables, when decayed, compose that kind of earth or mould which of all earths is best adapted to nourish vegetable life, and indeed without which no fertility can be expected. Hence, if in a sandy soil that plant which can support such a soil be cultivated, and left to rot, then another crop of the same suc-

markable

ceed, and be ploughed in, by degrees the sandy soil will become mixed with vegetable earth, and after a while will be capable of nourishing whatever plants are committed to its bosom. A remarkable instance of the formation of soil is in the garden of the Convent on Mount Sinai, where the sweepings of the stone-floor of the convent formed the first earth, which by the additional putrefaction of vegetables &c. used in the convent, has at length formed a capital garden.

Vegetation is no less strong in the water than on land; in the ocean than on the plains: nor is it confined to plants, but produces large trees of solid wood. Of these we must expect to continue ignorant, except as accident discloses them. Can those which grow in perpetual darkness be stimulated by light? Do those exhibit variations of irritability which dwell in a medium invariably cold and dense, often perhaps stagnant and motionless? These and other enquiries are at present beyond our information.

Thus we have endeavoured to illustrate the generation, growth, and structure, of vegetables; their numbers forbid extending our disquisitions, and their properties are various as their numbers. We shall hereafter offer a selection of the most remarkable, at present only observing, that though we are under great obligations to vegetables in general, yet that some are *poisonous*, and in certain instances so strongly as to poison the air around them. We have an extraordinary, but perhaps exaggerated relation of a great tree of this nature in Japan, to which only condemned criminals are sent to gather its gum: they approach the tree to windward, yet few return to claim exemption from farther punishment. Another, and a well-authenticated instance, is the manchineel tree, under whose branches should an unwary traveller take refuge, the drops of rain falling from them, would at least corrode and blister his skin, if he escaped so. Our own yew has similar, though very greatly inferior, reputation. Nor should opium be forgotten, which is yielded by the white poppy, cultivated for that purpose in the East: in small quantities this promotes sleep, in large quantities fatal sleep. By habit, the Eastern people can eat it in lumps, and drinking a glass of cold water after it, experience merely intoxication; yet gradually it shortens their days, produces decrepitude, and undermines the natural powers. In short, the number of plants having poisonous qualities is considerable: and we are happy in this count y in having but a small proportion, and those of no extraordinary virulence.

THE
BOTANICAL PRECEPTOR.

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P A R T II.
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OF VEGETABLES, AND THEIR PARTS.

VEGETABLES are divisible into seven families or tribes

1. MUSHROOMS, *fungi*.
2. FLAGS, *algæ*; whose root, leaf, and stem are all one.
3. MOSSES, *musci*; whose antheræ have no filaments, and are placed at a distance from the female flower, and whose seeds also want their proper tunic and cotyledons.
4. FERNS, *filices*; whose fructification is on the back of the (*frondes*) leaves.
5. GRASSES, *gramina*; which have simple leaves, a jointed stem, a glumose calyx, and a single seed.
6. PALMS, *palmae*; which have simple stems that are *frondose*; or have their kind of leaves, and their fructifications, on a spadix issuing from a sheath.
7. PLANTS, which includes all not comprised in the other divisions. These are,

Herbaceous, when they die down to the root every year; for in the perennial kinds, the buds are all produced on the root below the surface of the ground.

Shrubs, when their stems come up *without* Buds.

Trees, when their stems come up *with* Buds.

Nature has put no limits between a tree and a shrub, which is only a vulgar distinction. This *Linnaeus* acknowledges, and admits that his own distinction, though he thinks it the *best*, is nevertheless exceptionable; inasmuch as there are seldom any buds upon large trees in *India*; which must therefore by this definition, notwithstanding their great height, be ranked with shrubs. But we are to remark that a tree is a perennial plant, which rises to a great height, with a simple, woody, and durable stem, or trunk. By these characters are trees with great accuracy distinguished from herbs whose stems are frequently compound, herbaceous, or succulent, and die down to the root every year.

Upon these obvious and striking differences was founded the very ancient division of vegetables into herbs and trees; which has obtained a principal place in almost every system, except that of Linnæus, which mixes herbs and trees promiscuously together. The distinction into trees and shrubs is neither so obvious, nor are its limits so accurately ascertained. Of the numerous characteristic differences which have been suggested by botanical writers, not one is perfectly satisfactory.

Vegetables are divisible into, 1. The *Root*. 2. The *Herb* or *Plant* itself. 3. The *Fruetification*.

O F R O O T S.

THE root, whose office is to attract and receive nourishment, and which also produces the herb, with its fructification, consists of two parts, the *stock* or body; the *radicle* or little root.

In bulbous plants, as the tulip, onion, and lilly, what we ignorantly call the root, is, in fact, a bulb, or *hybernaculum*, which encloses and secures the embryo, or future shoot.

At the lower part of this bulb, may be observed a fleshy knob, or tubercle, from which proceeds a number of fibres, or threads. This knob, with the fibres attached to, and hanging from it, is, properly speaking, the true root: the upper part being only the cradle or nursery of the stem, which after the bulb has repaired a certain number of times, perishes; but not till it has produced at its sides a number of smaller bulbs, or *suckers*.

Uniform and constant as nature is in all her productions, there are many perennial roots, which become annual, when transplanted into cold climates, in the same manner as the stalks of herbaceous vegetables perish in autumn, while the root continues in full vigour: sometimes even in such circumstances it will not only divest itself of its woody stem, and become herbaceous, but be metamorphosed, in every respect, into an annual plant, and lose both its stem and root at the end of one year. Culture, on the other hand, may prolong the life of annuals. Thus, M. Duhamel mentions a root of barley, which put forth new stalks after the old ones were cut down in harvest, and produced a spike of flowers the following year.

THE BODY, *caudex*, of the root both ascends and descends.

The ascending body rises gradually above ground, often as a trunk, and produces the herb or plant.

The descending body strikes gradually downward into the ground, and puts forth roots or radicles. It has been distinguished, according to its structure, as

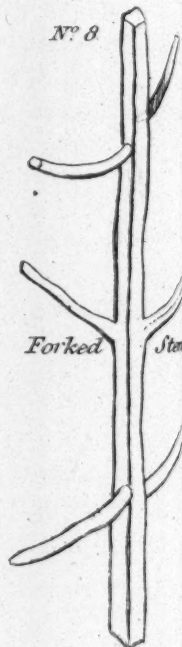
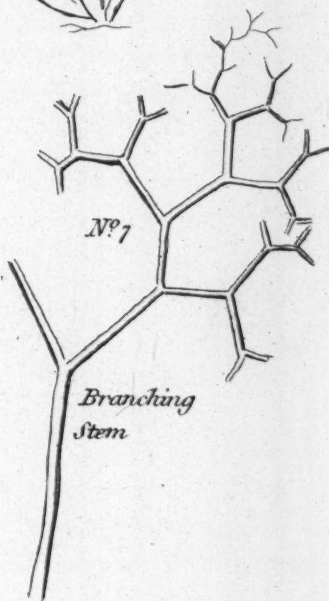
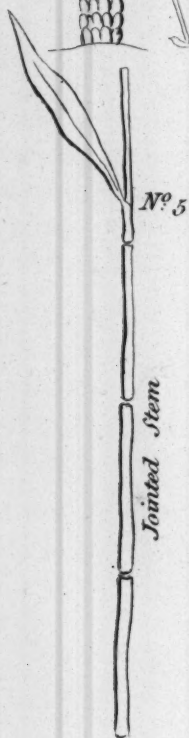
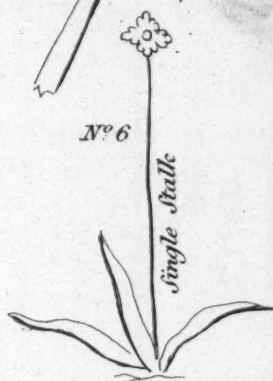
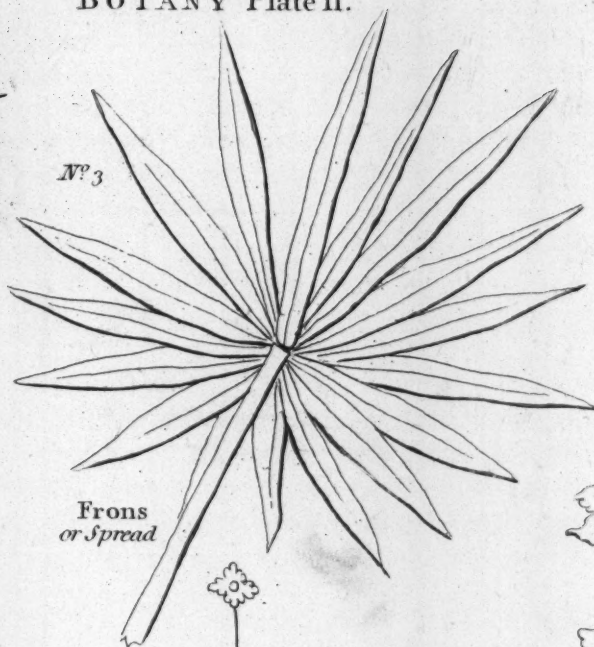
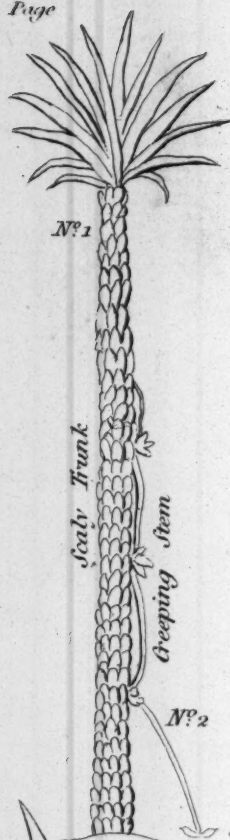
Perpendicular, when it runs directly downwards.

Horizontal.



Page

BOTANY Plate II.



TRUNKS

Horizontal, when it extends itself transversely under the earth.
Simple, when it has no subdivisions.

Branching, ramose; when it is divided into lateral branches.

Spindle-shaped, fusiform; when it is oblong, thick, and tapering, as in the carrot and parsnip.

Creeping, repent; when it stretches to a distance horizontally, and puts forth radicles from space to space.

Bitten off, præmorse; when the lower part ends suddenly, as in *scabious* and *valerian*.

The RADICLE, *radicula*; is the fibrous part of the root, which terminates the descending body, and enables the root to draw nourishment for the support of the vegetable.

The tuberous or knobbed roots, are fleshy, solid, hard, commonly thicker than the base of the stem, and composed either of one knob, as in radish, turnip, or carrot; or of many collected into a bunch, as in pœony, sun-flower, and drop-wort: in the last of which plants, several small roundish bodies hang, or are fastened together by a number of slender strings, or filaments.

In tuberous roots, the radicles or small stringy roots are generally dispersed over the whole surface: in which respect they differ essentially from bulbous roots, in which the radicles are confined to the bottom of the bulb; that part only being the true and genuine root; the bulb itself serving as a large bud under ground, for inclosing and protecting the embryo plant.

Fibrous roots are slenderer than the base of the trunk, and are either divided by equal branches, as in the greater number of trees, in which likewise the substance is woody; or consist of a number of single fibres, like hairs, which proceed from the small knot, or base of the stem; as in many grasses: this is termed *radix capillacea*.

The radicle is, in fact, the principal and essential part of every root, and is therefore never wanting, not even in those plants improperly styled imperfect: for the mosses, lichens, and submarine plants discover a remarkable analogy in the *lamellæ* and *strice* by which they adhere to the bodies placed under them, to the radicles, or stringy fibres, which are present in other plants.

THE ROOT OF A PLANT

Is to be considered in respect to the ascending and descending body and radicles. Roots are farther distinguished into,

Those consisting of a BULB, *bulbose*; and these are either,

Scaly, *squamose*; as in the lilly.

Coated, *tunicate*; as in the onion.

Double, *duplicate*; as in *fritillary*.

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Solid,

Solid, as in *tulip*.

Knobbed, *tuberosæ*; and these are either,

Handed, *palmate*; as in *orchis*.

Bundled, *fasciculate*; as in *pæny*; or,

Hanging, *pendulous*; as in wild olive.

Jointed, *articulate*; as *lathyræa*, wood sorrel, and toothwort.

OF THE HERB.

The HERB is a part of the vegetable arising from the root, and terminated by the fructification. It comprehends,

1. The TRUNK which serves to multiply the herb, and leads immediately from the root to the fructification.

2. The LEAVES, whose office is to transpire and attract like the lungs in animals, and to afford shade.

The PROPS, *fulcra*; which serve as holdings to strengthen the plant; but may be taken off without destroying it.

The WINTERINGS, *i. e.* the bulbs and buds; each of which is a compendium of the herb upon its root before it begins to grow.

OF THE TRUNK.

The TRUNK is that which produces the leaves and fructification: its kinds are reduced to seven:

A STEM, *caulis*, is the proper trunk of the herb, and elevates the leaves and fructification: it is either *simple* or *compound*.

SIMPLE stems are such as proceed in a continued series towards their summits: And these may be,

ENTIRE, *integri*; or,

BRANCHY, *ramosæ*.

ENTIRE; when they have scarce any branches. These may be, Naked, when destitute of leaves.

Leafy, when furnished with leaves.

Bending different ways, *i. e.* at every joint.

Twining, when they ascend spirally by the branch of some other plant. These wind either to the left, or to the right.

Reclined, when they bend towards the earth.

Lying on the ground, when horizontal.

Creeping, when lying, on the ground, they put forth roots at certain intervals.

Having long shoots, when creeping and almost naked.

Parasitic, when they grow on some other plant.

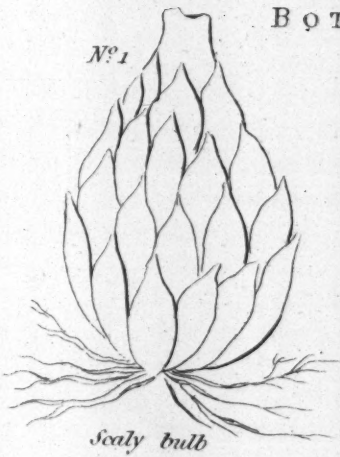
Double-edged, when they have two opposite angles; and also having two, three, four, five, or many angles.

Three-square, also when they have three, four, five or many sides or angles.

Round.

Furrowed,

N^o 1



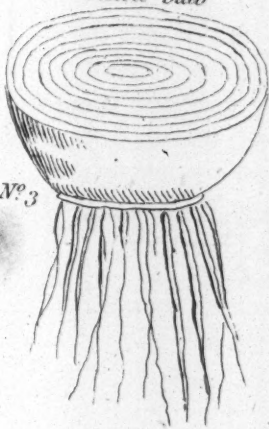
Scaly bulb

N^o 2



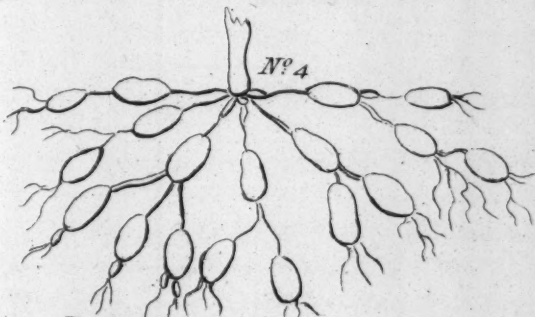
Solid Bulb

Coated bulb



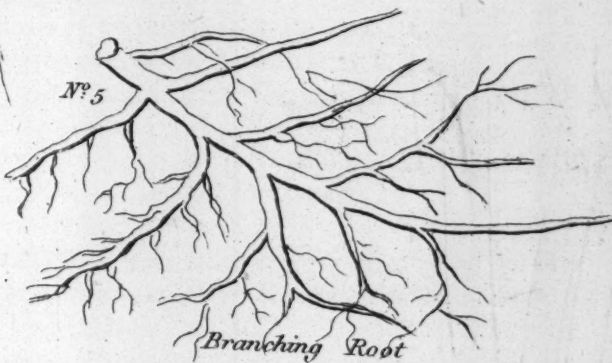
N^o 3

N^o 4



Pendulous Tuberose Root

N^o 5



Branching Root

N^o 6

Spindle-shaped Root



N^o 7

Creeping

Root



ROOTS



Furrowed, *i. e.* with broad deep grooves.

Streaked, *i. e.* with very thin hollow lines.

Smooth, or *shaggy*, having a down of soft hairs upon them.

Rough, when covered with little projecting points.

Bristly, when covered with stiff hair.

BRANCHY, *i. e.* having lateral branches: and these are,

Ascending, spreading in two rows.

Having *arms*; when each pair is crossed by the pair next above or below it.

Very branchy.

Propt, when the branches descend to the root.

Proliferous, when they send forth branches only from the centre of the apex.

The rest as in *entire* stems.

COMPOUND stems are subdivided into small branches, and diminish as they ascend. These are either,

Forked, always into two parts;

Subdivided, when divided into branches irregularly, or without order; or,

Jointed, when they are distinguished from space to space by knots or joints.

A STRAW, *culmus*, is the proper stem of a grass, elevating the leaves and fructification: It admits of most of the distinctions already given for a stem; besides which it may be either,

Without knots; when it is continuous, and not intercepted by joints.

Jointed, when it is connected by various joints.

Scaly, when it is covered with imbricate scales.

A STALK, *scapus*; is an *universal* trunk, raising the fructification but not the leaves; as in *Narcissus*.

A FOOT-STALK, *peduncle*; of a *flower*, is a *partial* trunk, raising the fructification but not the leaves.

Pedicellus, is a *partial peduncle*.

The determination of peduncles respects *place* and *manner*.

Determination respecting *place* shows where the base of the peduncle is inserted into the plant.

Peduncles belong either to the ROOT, to the STEM, or to the BRANCHES; or they terminate the branches or stem. Also they are,

Axillary, coming out from the wings, between the leaf and the stem, or between the branch and the stem.

Solitary, when there comes but one from the same place.

Scattered, when they are numerous, and without order.

Determination in respect to *manner*, shows how the flowers are borne and connected on the summits of the peduncles: and in this respect, bear *one*, *two*, *three*, or *many* flowers, according to the fructifications on a single peduncle.

A **BUNCH**, is a collection of flowers that are erect, parallel, and close.

A **LITTLE HEAD**, is a number of flowers collected almost into a globular form.

A **SPIKE**, has sessile flowers alternate and dispersed about a common peduncle that is simple. It called a *single-rowed spike*, when the flowers are turned *one way*: and a *double-rowed spike*, when the flowers stand *two ways*.

A **CORYMBUS**, is a kind of spike, the flowers of which have each its proper little *footstalk*, raised to a proportional height.

A **PANICLE**, is a fructification dispersed on peduncles variously subdivided. It is a *diffuse* panicle, when the little footstalks *spread asunder*; a *confined* panicle when they stand close together.

A **THYRSUS**, is a panicle contracted into an ovate form.

A **RACEMUS**, consists of a peduncle that has short lateral branches; as in currants.

A **WHORL**, *verticillus*, expresses a number of flowers that have very short footstalks, and are produced in rings round the stems.

A **FOOT-STALK OF A LEAF**, fastens the leaves, but not the flowers; which distinguishes it from a peduncle, which is the foot-stalk fastening a flower, not the leaves.

OF SIMPLE LEAVES.

LEAVES are 1. *Simple*. 2. *Compound*. 3. *Determinate*.

SIMPLE leaves have only a single leaf on a foot-stalk. They differ in respect to *circumscription* or *external form*, *angles*, *sinus*, *apices* or *points*, *margin*, *superficies*, and *substance*.

CIRCUMSCRIPTION considers the form of the circumference. In which respect, leaves are,

Round, *orbiculate*; when the circumference is circular.

Roundish, *subrotund*; when the figure approaches a circle.

Egg-shaped, *ovate*; when the longer diameter exceeds the transverse; and the base forms the segment of a circle, the point being narrower.

Oval or elliptic; when the longer diameter exceeds the transverse, and the form of both the upper and lower extremity is narrower than the segment of a circle.

Parabolic, when the longer diameter exceeds the transverse, and the form contracting from the base upwards becomes *half egg-shaped*.

Spatulate, resembling a *spatula*; when the form is roundish, but lengthened out by a narrower linear base.

Wedge-shaped,

HERBARIUM





Orb like



Roundish



Ovate



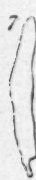
Oval



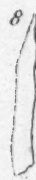
Oblong



Lance-like



Linear



Awt-shaped



Kidney-shaped



Heart-shaped



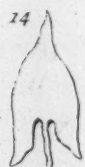
Crescent-shaped



Triangular



Arrow-shaped

Heart & Arrow
Shaped.

Spear-shaped



Cleft



Three lobed



bitten off



Lobated



Five angled



Gnawed



Hand-like



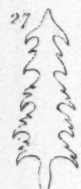
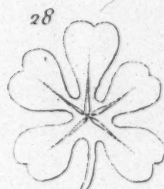
Winged



Irregular incisions



Scolloped

Indented and
Scolloped.Scolloped
backwards.

Parted



Waved.



Toothed

SIMPLE LEAVES.



Saw-edged



Double saw-edged



Double notched



Cartilaginous



Sharply notched



Bluntly notched



Pinnate



Notched



Curled



Blunted



Sharp



Pointed



Blunt with a point



Sharply nicked



Wedge shaped nicked.



Blunt



Hairy



Downy



Bristled.



like Eye lashes



Wrinkled



Veined



Nerved



Pimpled



Tongue shaped



Falchion shaped



Ax shaped



Deltoid



Three sided



Channeled



Rounded



Furrowed.



Wedge-shaped, *cuneiform*; when the longer diameter exceeds the transverse, and the form gradually contracts downwards.

Oblong, when the longer diameter is twice, thrice, &c. the length of the transverse, and the form of the extremities is narrower than the segment of a circle.

ANGLES are the prominent parts of an horizontal leaf. In respect to these, a leaf is,

Spear-headed, *Lanceolate*; when the form is oblong, narrowing gradually at each end towards the extremity.

Linear; when of the same breadth throughout, though sometimes narrowing at the extremities only.

Chaffy, *acerose*; when it is linear and persisting; as in *pinus*, and *juniper*.

Awl-shaped, *subulate*; when linear below, but gradually contracting towards the top.

Three-cornered, *triangular*; when formed by three prominent angles.

Four-cornered, five-cornered, &c. *quadrangular*, *quinquangular*, &c. when formed by four or five prominent angles.

Shaped like a Delta, *deltoid*; when the figure having four angles, of which the two lateral ones are nearer the center than those at the extremities.

Round, *rotund*; when without angles.

A HOLLOW, *sinus*; is a term used to express those openings or cavities in leaves which distinguish them into parts: In respect to these, Leaves are said to be,

Kidney-shaped, *reniform*; when they are roundish, and hollowed at the base.

Heart-shaped, *cordiform*; when ovate, and hollowed at the base, and the hinder and lower parts have no angles.

Moon-shaped, *lunulate*; when round, and hollowed at the base, and have no angles at the lower part.

Javelin-shaped, *hastate*; when triangular, the base and sides hollowed, the angles spreading.

Pandure-shaped, *panduræform*; when oblong, broader above than below, and contracted in the sides.

Cloven, *fissa*; when divided by linear sinusses, having their margins straight; from the number of such divisions they are called *bifid*, *trifid*, *quadrifid*, *multifid*, &c. cut into *two*, *three*, *four*, *five*, or *many* segments.

Lobed, *lobate*; when divided to the middle into parts that stand wide from each other, and have their margins convex, from the number of these they are called *bilobe*, *trilobe*, *quadrilobe*, or *quinelobe*; consisting of *two*, *three*, *four*, or *five* lobes.

Handed, *palmate*: when cut longitudinally into many parts nearly equal; the divisions extending themselves downward, almost

most to the base where the segments cohere: somewhat as fingers do to the hand.

Cut into wings, *pinatifid*; when divided transversely into *lacinia*, long and horizontal.

Lyre-shaped, *lyrate*; when divided transversely into *lacinia*, of which the upper ones are larger, and the lower ones farther asunder.

Jagged, *laciniate*; when variously divided into parts indeterminedly subdivided.

Hollowed, *sinuate*; with broad and spreading openings in the sides.

Divided, *partite*; when separated down to the base. From the number of the divisions they are *bipartite*, *tripartite*, *quadripartite*, *quinquepartite*, or *multipartite*; divided into *two*, *three*, *four*, *five*, or *many* parts.

Entire, *integra*; when without divisions, and having no sinus or opening. This stands opposed to all the kinds of the divided leaves before described.

TIP or POINT, *apex*; the extremity in which the leaf terminates. Leaves, in respect to their apices or points, are called,

Lopped, *truncate*; when they end in a transverse line.

Bitten in the fore part, *præmorse*; when very obtuse, and terminated by unequal notches or incisions.

Blunted, *retuse*; when they terminate in an obtuse sinus.

Nicked, when they terminate in a notch.

Blunt, *obtusè*; when they terminate as it were within a segment of a circle.

Sharp, *acute*; when they terminate in an acute angle.

Pointed, *acuminate*; when they terminate sharp.

Claspered, *cirrhone*; when they terminate in a clasper or tendril.

The MARGIN of a leaf is the boundary of its sides, exclusive of its disk. Leaves, in respect to their margin are,

Thorny or prickly, *spinose*; when the margin of the leaf ends in firm points.

Unarmed or smooth, *inerm*; which is opposed to thorny.

Toothed or indented, *dentate*; when the margin ends in horizontal points, of the consistence of the leaf.

Saw-like, *ferrate*; when the margin is cut into sharp angles, pointing towards the extremity of the leaf: If they point towards the base, the leaf is said to be saw-like backwards, *retrosum ferrate*.

Doubly saw-like, *duplicato-ferrate*; when there is a two-fold serrature, the less upon the greater.

Notched, *crenate*; when the margin is cut into angles, that point towards neither of the extremities: these are *obtusely crenate*

nate or notched, when the angles are rounded: or acutely notched or crenate, when the angles are pointed.

Doubly notched, *duplicato-crenate*; when the notches are two-fold, the less upon the greater.

Bending back again, *repand*; when the margin is terminated with angles and interjacent hollows, that form a serpentine edge.

Griftly, *cartilaginous*; when the edge of the leaf is strengthened by a border tougher than the substance of the leaf.

Fringed as eye-lashes, *ciliate*; when the margin is surrounded with bristles.

Rent or torn, *lacerate*; when the margin is cut into unlike segments.

Gnawed, *erose*; when the leaf is sinuate, and has very small obtuse hollows on its margin.

Very entire, *integerrima*; the margin quite free from notches.

SURFACE, *superficies*, is the outside of the disk of the leaf; and respects both the face of the leaf or supine disk, and the back of it, or prone disk. Leaves in respect to their surface, are,

Clammy, *viscid*; smeared over with a tenacious, sticky juice.

Downy, *tomentose*; covered with a nap of interwoven hairs.

Woolly, *lanate*; covered as with a spider's web.

Hairy, *pilose*; when covered with distinct hairs of some length.

Rough with hair, *hirsute*; hairy in a great degree.

Shaggy, *villose*; covered with a coarser hair or shag.

Rough, *hispid*; covered with a stiffish sort of bristles that break easily.

Rugged, *scabrous*; covered with little knobs.

Prickly, *aculeate*; when beset with sharp and stiff points.

Streaked, *striate*; scored longitudinally with parallel lines.

Nipply, *pappillose*; covered with *vesicles*, little bladders.

Dotted, *punctate*; besprinkled with hollow points or dots.

Bright, *nitid*; the smoothness of the leaves causing them to shine.

Plaited, *plicate*; when the disk of the leaf rises and falls in angles towards the margin.

Waved, *undulate*; when the disk of the leaf rises and falls in convexities towards the margin.

Curled, *crispe*. All curled leaves are monsters or diseases.

Wrinkled, *rugose*; when the substance between the veins of the leaves is obliged to rise.

Hollow, *concave*; when the disk is depressed.

Veiny, *venose*; the vessels branch all over the leaves, and their joinings appear to the naked eye.

Nervose; having simple unbranched vessels extending themselves from the base to the apex.

Coloured; changing their green for some other colour; as in *amaranthus tricolor* (three coloured).

Smooth, *glabra*; void of inequality.

The SUBSTANCE of a leaf respects the conditions of its sides:
In this respect leaves, are,

Round like a pillar, *teretes*; for the most part cylindrical.

Like a halved cylinder, *femi-cylindric*; round on one side and flat on the other.

Like a Tube or Pipe, *tubulose*; hollow within.

Fleshy or succulent, *carnose*; filled with a pulp.

Compressed, flattened; when the substance of the leaf becomes greater than the disk.

Level, *plane*; when both surfaces are every where parallel.

Bunched, *gibbous*; when both surfaces are convex.

Convex, rounding; when the disk rises higher than the sides.

Pressed down, *deprest*; when the sides rise higher than the disk.

Channelled, *canaliculate*; when a deep furrow runs along it.

Double-faced, *ancipites*; when the disk is convex, and there are two prominent longitudinal angles.

Sword-shaped, *ensiform*; when double-faced and growing narrower from the base to the apex.

Falchion-shaped, *acinaciform*; when fleshy and compressed with one edge convex and narrow, the other straighter and broader.

Hatchet-shaped, *dolabriform*; when roundish, compressed and obtuse, gibbous outwardly, with a sharp edge, and taper toward the lower part.

Tongue-shaped, *linguiform*; when linear, fleshy, obtuse, convex underneath; often with a cartilaginous margin.

Three-cornered, *triquetrous*; with three flat longitudinal sides.

Furrowed, *fulcate*; when scored longitudinally with numerous ridges.

Keeled, *carinate*; when the prone part of the disk is prominent longitudinally.

Membranaceous; when they have no perceptible pulp between the two surfaces.

OF COMPOUND LEAVES,

A LEAF is said to be COMPOUND, when there are more than one on a foot-stalk.

COMPOUND leaves are to be considered in respect to *structure* and *degree*.

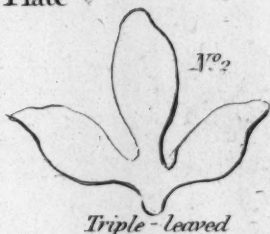
By the STRUCTURE of a compound leaf is understood the insertion



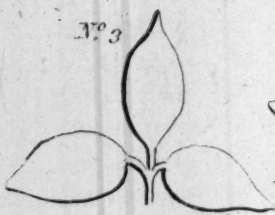
BOTANY Plate



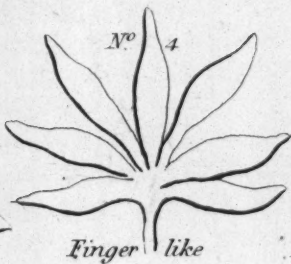
Double-leaved



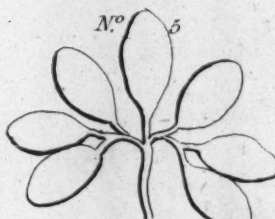
Triple-leaved



Triple-leaved with footstalks



Finger-like



Toe-like



Winged ending odd



Winged ending abrupt



Winged alternately



Winged interruptedly



Winged with tendrils



Winged conjugately



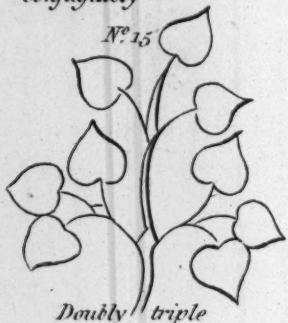
Winged decursively



Winged jointedly



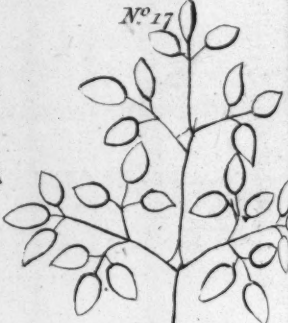
Lyre-like



Doubly triple



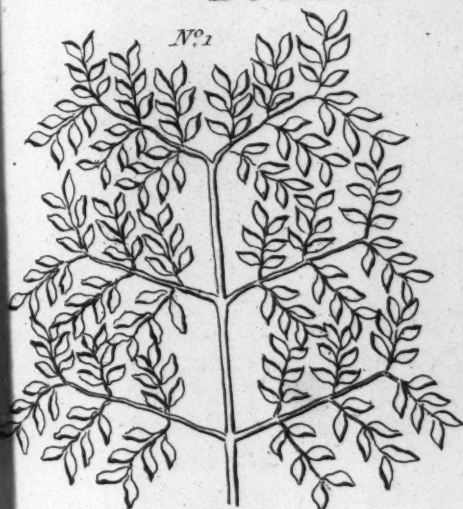
Doubly winged



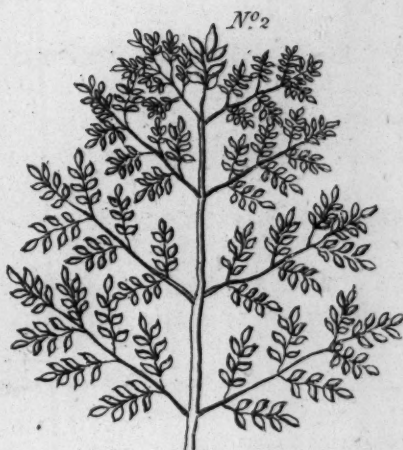
Triply triple

COMPOUND LEAVES.



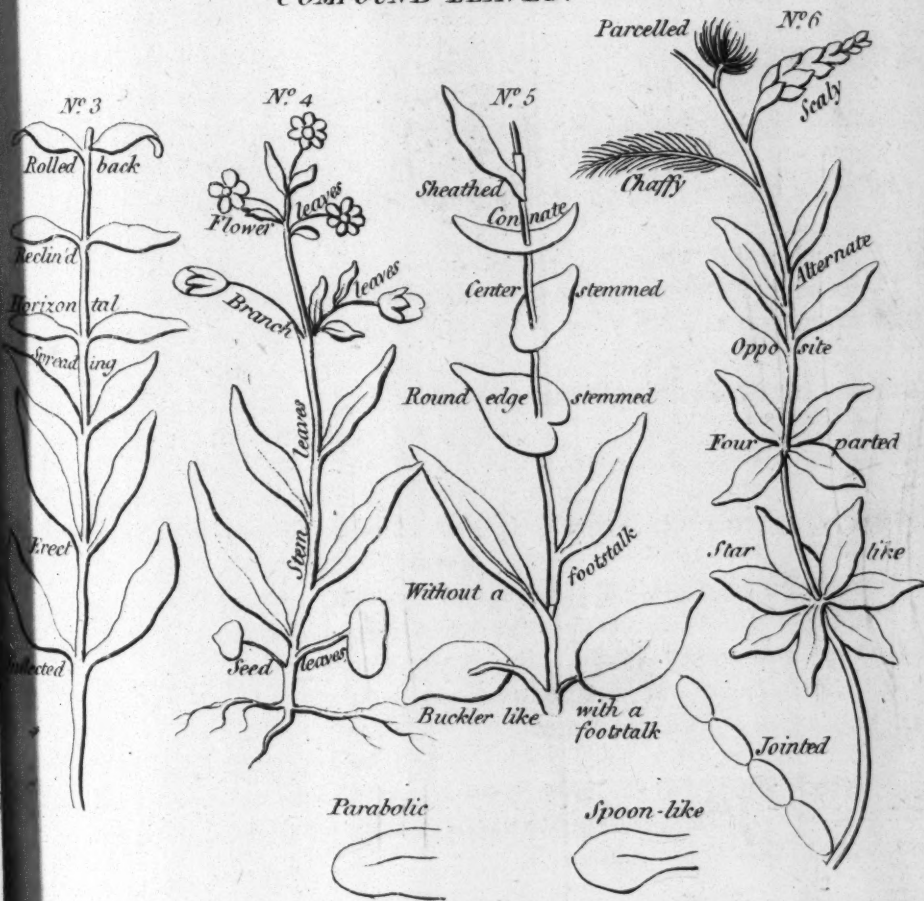


Triply winged abrupt



Triply winged ending odd

COMPOUND LEAVES.



DETERMINATE LEAVES.



sertion of the lesser leaves or folioles, of which it is compounded; in this respect leaves are called,

Compound; when a single footstalk furnishes more than one leaf.

Jointed, articulate; when one leaf grows from the top of another.

Fingered, digitate; when the apex of a single footstalk connects many lesser leaves, these are termed *binate, ternate, or quintate, i. e.* growing *two, three, or five*, together.

Winged, pinnate; when the sides of a single foot-stalk connect many small leaves.

Winged with an odd one; when terminated by an odd leaf.

A *pinnate* or clasped leaf, *cirrrose*; when it terminates in a clasper.

An *abrupt* pinnate leaf; when terminated neither by a small leaf nor a clasper.

Winged oppositely; when the upper leaves stand opposite to each other.

Winged alternately; when the lesser leaves stand alternately.

Winged interruptedly; when the lesser leaves are alternately less.

Winged articulately; when the foot-stalk common to all the lesser leaves is jointed.

Winged decursively; when the lesser leaves extend themselves downwards along the foot-stalk.

Conjugate; when the winged leaf consists of two lesser leaves only.

DEGREE, in a compound leaf, respects the subdivision of the common petiole or foot-stalk. In respect to this, leaves are,

Decomound; when a foot-stalk once divided connects many lesser leaves.

Bigeminate; when a divided and forked foot-stalk connects four smaller leaves on its points.

Biternate or *duplicato-ternate*; when there are three small leaves on a foot-stalk, and each small leaf is ternate.

Bipinnate, or doubly winged; when the smaller leaves of a winged leaf are also winged.

Foot-shaped, pedate or branching; when a bifid foot-stalk connects many small leaves on its inside only.

Supra-decompound; when many small leaves are borne on a footstalk, that has been any number of times subdivided.

Triply triple, triternate; when a foot-stalk bears three lesser leaves, each of them triple.

Triply winged, tripinnate; when a foot-stalk bears many lesser leaves each of which are double winged.

OF DETERMINATE LEAVES.

THE DETERMINATION of leaves is understood of their character, as arising from their *place, situation, insertion, or direction.*

By the place of a leaf is meant the part where it is fastened to the plant. In respect to which leaves are called,

Seed-leaves, *seminal*; which are the first that appear.

Root-leaves, *radical*; proceeding from the root.

Stem-leaves, *cauline*; growing on the stem.

Branch-leaves, *rameous*; growing on the branches.

Axillary; placed at the coming out of the branches.

Flower-leaves, *floral*; placed at the coming out of the flower.

SITUATION signifies the disposition of the leaves on the stem of the plant. In respect to which, leaves are called,

Starry, *stellate*; or whorled, *verticillate*; when the stalk is surrounded in whorles by more than two leaves; and these receive the denomination of *tern, quatern, quine*; *three, four, or five, &c.* according to the number of leaves of which the star or whorl is composed.

Opposite; when the cauline or stem-leaves come out in pairs facing each other, and each pair is crossed by the next, so that they point four different ways.

Alternate; when they come out singly; and so follow.

Scattered, *sparced*; when they come out in plenty, without order.

Crowded, *confert*; when they almost cover the branches, and leave hardly any space between them.

Imbricate; when they are crowded and erect, each covering a part of the following one, like tiles on a roof.

Bundled, *fasciculate*; when many come out from the same point.

Distich, *in two rows*; when the leaves respect two sides of the branches only.

In respect to their INSERTION (which is usually at the base) leaves are called,

Buckler-like, *peltate*; when the foot-stalk is inserted into the disk of the leaf, not into its base or margin.

Petiolate; when the foot-stalk is fastened to the leaf at the margin of the base.

Squat, *sessile*; when the leaf has no foot-stalk, but is fastened immediately to the stem.

Running down, *decurrent*; when the base of a sessile leaf extends itself downwards along the stem beyond the proper base or termination of the leaf.

Embracing

Embracing the stalk, *amplexicaul*; when the base of the leaf embraces the sides of the stem crosswise on both sides; or, *semi-amplexicaul*, *half embracing the stalk*; which is the same in a less degree.

Centre-stemmed, *perfoliate*; when the base of the leaf is continued so as to embrace the stem all round.

Growing together, *connate*; when two opposite leaves join, and are united in one.

Vaginant, when the base of the leaf forms a *vagina*, or sheath, for the branch.

In respect to their DIRECTION, leaves are called,

Adverse; when their sides are not turned towards heaven, but towards the south.

Oblique; when the base of the leaf looks towards heaven, and the apex or tip towards the horizon.

Bending inwards, *inflex*; when the leaf is bended upward toward the stem.

Adpressed; when the disk of the leaf lies close to the stem.

Erect; when they form a small angle with the stem.

Spreading, *patent*; when they make an acute angle with the stem.

Horizontal; when they stand at right angles with the stem.

Reclined, or, *reflex*; when bowed downwards, so that the apex or tip is lower than the base.

Rowled back, *revolute*; when rowled downwards.

Hanging down, *dependent*; pointing to the ground.

Rooting, *radicant*; when the leaves strike root.

Floating, *natant*; on the surface of the water.

Sunk, *demerse*; beneath the surface of the water.

OF THE FULCRA OF PLANTS.

A PROP, *fulcrum*; is a term used to express those small parts of plants, of which the chief use is to support them.

Fulcra are of seven kinds;

1. A SCALE OR SMALL LEAF, *stipula*, stationed on each side the base of the foot-stalks, when they first appear.

2. A FLORAL LEAF, *bractea*, so called when it differs in shape and colour from the rest.

3. A THORN, *spina*, a sharp weapon, protruded from the wood of the plant.

4. A PRICKLE, *aculeus*; a weapon of the same sort, proceeding from the bark of the plant only.

5. A CLASPER, OR TENDRIL, *cirrhus*; a thread-like spiral band, by which a plant clings to any other body.

6. A LITTLE GLAND, *glandula*; a kind of teat, serving for the excretion of some humour: its situation is commonly on the foot-stalks, the serratures of the leaves, or the tender stipulæ.

7. A HAIR, *pilus*; is a sort of bristle, serving as an excretory duct to the plants.

Claspers, says the ingenious Dr. Grew, are not like trunk-roots, a mean betwixt a root and a trunk, but a compound of both, as may be gathered from their circumvolutions, in which they mutually ascend and descend.

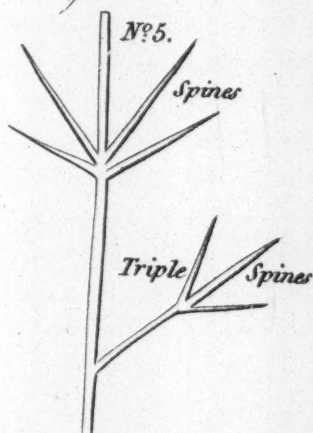
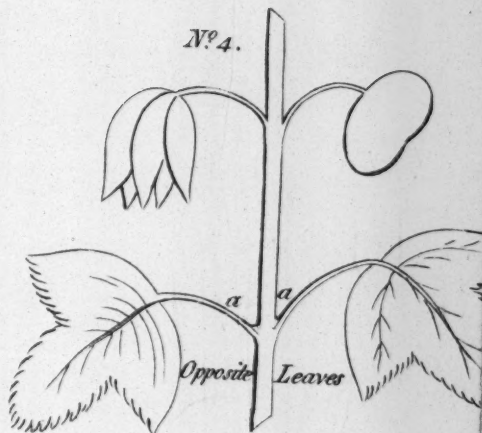
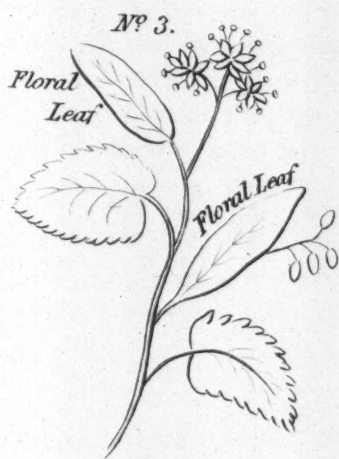
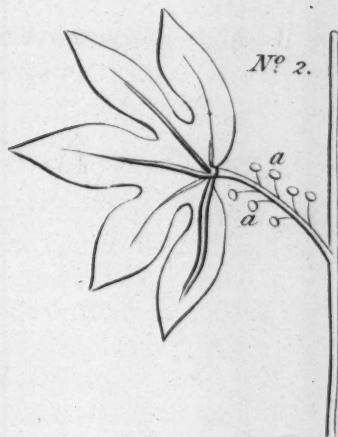
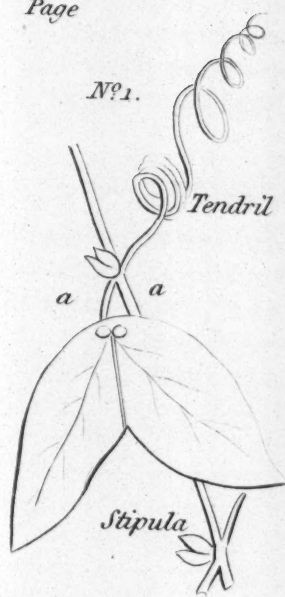
In the mounting of the trunk, continues the same author, claspers serve for support. Thus in vines, the branches, being very long, fragile and slender, would be liable to frequent breaking, unless, by means of their claspers, they were mutually contained together; so that the whole is divided betwixt the gardener and Nature: the former, with his ligaments of leather, secures the main branches; and Nature, with those of her own providing, secures the less. Their aptitude to this end is seen in their convolutions, 'a motion not proper to any other part; and also in their toughness, which is so much the more remarkable, as they are more slender than the branches from which they proceed.

In the trailing of the trunk, tendrils serve for stabiliment and shade. Thus in cucumbers, the trunk and branches being long and fragile, would be driven to and fro by the winds, to the great prejudice both of themselves and their tender fruits, were they not by these ligaments held fast together, and preserved in good association and fellowship. The same claspers serve likewise for shade: so that a natural harbour is formed by the branches of the cucumber, in the same manner

as

Page

BOTANY Plate.



SUPPORTS.

Triple Prickles.



as an artificial one is made by tangling together the twigs of trees ; for the branches, by the linking of their clasps, being couched together, the tender fruits lie under the umbrage of a bower made of their own leaves.

Most of the pea-bloom flowers have twining clasps, that is, which wind to the right and back again.

OF THE HYBERNACULA OF PLANTS.

THE WINTER-LODGE, or *hybernaculum*, is that part of a plant which incloses and protects the future shoot from injuries. It is of two kinds, a *bulb*, *bulbus* ; and a *bud*, *gemma*.

A BULB, is an *hybernacle*, placed on the root ; it is

Squamosæ, when it consists of thin plates or scales.

Solid, when it consists of a *solid* substance.

Tunicate, when it consists of many *tunics* or coats.

Articulate or jointed, when it consists of plates linked together.

A BUD, *gemma*, is an *hybernacle* placed on the stem and branches : it consists either of *stipulæ*, of foot-stalks, of the rudiments of leaves, or of scales of the bark.

Buds are of various kinds. In the generality of plants, they produce both leaves and flowers ; but in some, they bear leaves only ; others bear *leaves* and *flowers* distinctly.

N.B. Several plants have *no* buds.

In cold countries, there are few plants without buds ; in hot countries, few have any.

THE
BOTANICAL PRECEPTOR.

PART III.

OF THE SEVEN PARTS OF FRUCTIFICATION.

BY fructification we understand both the *flower* and *fruit* of plants; which cannot well be separated: For though the fruit does not swell and ripen till after the flower is fallen, its rudiment, or beginning, is in the flower, of which it properly makes a part.

1. The FLOWER-CUP, or *calyx*.
2. The LEAVES OF THE FLOWER, *corolla*.
3. The THREADS, *stamina*, vulgarly called the CHIVES.
4. The POINTAL, or STYLE, *pistillum*.
5. The SEED-VESSEL, *pericarpium*.
6. The SEEDS, *semina*.
7. The RECEPTACLE, or *base*, on which the fructification is seated.

The Flower-cup, flower-leaves, and style, are properly parts of the *flower*; the seed-vessel, seed, and receptacle, are parts of the *fruit*.

The CALYX is the termination of the *outer BARK (cortex)* of the plant; which, after accompanying the trunk or stem through the branches, breaks out with the flower, in this new form. Its chief use is to inclose and protect the other parts. It has different appellations, according to circumstances; as,

1. A FLOWER-CUP, *perianthium*, when close to the fructification. If it include the *stamina*, and not the *germen*, it is the *perianthium of the flower*; if it include the *germen*, but not the *stamina*, it is the *perianthium of the fruit*; if it include both, it is the *perianthium of the fructification*.

2. A COVER, *involucrum*, when stationed at the foot of an umbel, distant from the flower; it is an universal *involucrum*, or COVER, if under the universal umbel; or a partial COVER, if under a partial umbel.

3. A CATKIN, *amentum*, when it proceeds from one common receptacle; resembling the chaff of an ear of corn.

4. A SHEATH, *spatha*, when it bursts lengthways, and puts forth what has been inclosed (*spadix*).

5. A HUSK, *glume*, in grasses, which it incloses with its valves; the BEARD issuing from the glume is called an *arista*.

6. A VEIL, *calyptra*, in mosses, where it is placed over the tops of the *stamina* (*antheræ*) and is hooded like a monk's cowl.

7. VOLVA, from its *involving*, or *enfolding*, in the *mushroom* tribe, or *fungi*, where it is membranaceous, and rent on all sides.

It is sometimes difficult to distinguish a calyx from the floral leaf (*bractea*); but they may be distinguished by this: a calyx always withers when the fruit is ripe, if not before; but the *bractea* remain longer. In many flowers the calyx is deciduous, dropping off when the flower begins to expand.

The COROLLA is the termination of the INNER BARK (*liber*); accompanying the fructification in the new form of painted leaves, serving as an inner work of defence, for the parts it incloses.

The LEAVES of which the corolla consists, are called *petals*; by which appellation they are conveniently distinguished from the great leaves of the plant, with which they might else be confounded.

If the Corolla be

OF ONE PETAL (*monopetalous*) it consists of two parts, *viz.* the tube, or lower part, usually tube-shaped; and the limb, or upper part, which spreads wider. The limb, according to its figure, is either, 1. BELL-SHAPED (*campanulate*); 2. FUNNEL-SHAPED (*infundibuliform*) *i.e.* conical, and standing on a tube; 3. SALVER-SHAPED (*hypocrateriform*) *i.e.* plain or flat, and standing on a tube; 4. WHEEL-SHAPED AND FLAT (*rotato-plane*) without a tube; or, 5. GAPING (*ringent*) *i.e.* irregular and with two lips.

But if the Corolla be

OF MANY PETALS (*polypetalous*) each petal consists of a CLAW (*ungis*) *i.e.* the lower part fastened to the base, and a THIN PLATE (*lamina*) *i.e.* the upper part usually spreading. A many-petalled corolla is CROSS-SHAPED (*cruciform*) when composed of four petals, equal and spreading; or BUTTERFLY-SHAPED (*papilionaceous*) when irregular, composed of four petals, of which the under one resembles the keel of a ship, the upper one rises, and the two side ones stand single.

To the corolla also belongs a part called the *nectarium*, which bears the honey; and belongs to the flower only. In some plants it is very large; in others it is scarcely discoverable, even with glasses. In some plants it is united with, and makes part of

the petals : in others it is detached from them. Its shape and situation also are various.

Between the calyx and corolla nature has put no absolute limits ; but they may be commonly distinguished by their position in respect of the stamina, the petals and stamina being ranged alternately ; whereas the segments of the calyx and the stamina correspond with each other.

The calyx, as proceeding from the cortex of the plant, is coarser and thicker than the corolla, which is produced by the soft, pliant, coloured inner bark.

OF THE STAMINA.

A STAMEN is the male part of a flower, designed for the preparation of the *pollen*.

Each *stamen* consists of two parts :

1. The FILAMENT (*filamentum*) or thread ; at the bottom connected with the flower ; at the top supporting the anthera or summit.

2. The SUMMIT itself (*anthera*) ; which incloses the pollen, and discharges it when mature.

The MEAL (*pollen*) contained within the anthera, is a fine powder secreted therein, destined for the impregnation of the *germen*.

Such flowers as want the stamen are called *female* ; such as have the stamen but want the pistil, are called *male* ; such as have both are called *hermaphrodite* ; and such as have neither are called *neuter*.

OF THE PISTILLUM.

THE PISTILLUM is an entrail of the plant, designed for the reception of the pollen, consisting of three parts :

1. The GERMEN ; usually at bottom, being the rudiment of the fruit accompanying the flower.

2. The STYLE ; in the middle, which elevates the stigma from the germen.

3. The STIGMA ; at the top, covered with moisture, for the breaking and detention of the pollen.

The pollen, we said, was destined to the impregnation of the germen, which is thus performed : the *antheræ*, which at the opening of the flower are whole, soon afterward burst open, and discharge the pollen, which is thereby scattered about the flower ; and lodging on the surface of the stigma, is there detained by the moisture belonging to that part : the grains of the pollen bursting and dissolving in this moisture (as has been observed by the microscope) are supposed to discharge a something that impregnates

pregnates the germen below. After this impregnation, the *germen* swells to a fruit, big with seeds, by which the species is continued.

OF THE PERICARPIUM.

The SEED-VESSEL (*pericarpium*) is the germen grown to maturity: big with seeds, which it discharges when ripe.

It is distinguished, according to circumstances; as,

A CAPSULE, *capsula*; a *hollow pericarpium*, divided in some determinate manner. The inclosure of the capsule, which covers the fruit externally, is called a *valvule*; the partitions, which divide the capsule into compartments or cells, are called *dissepiments*; the substance which passes through the capsule, and connects the several partitions and seeds, is called *columella*; and the cells, or compartments of the capsule, in which the seeds are lodged, are called *loculaments*.

A COB, *siliqua*; a pericarpium of two valves; in which the seeds are fastened along *both* the joinings of the valves.

A POD, *legumen*; also, a pericarpium of two valves; in which the seeds are fastened along *one* side only.

A CONCEPTACLE, *conceptaculum*; a pericarpium of a single valve, opening on one side, lengthways; the seeds not fastened to it.

A FLESHY OR PULPY PERICARPIUM, without valve, *drupa*; containing a *stone*.

A FLESHY OR PULPY PERICARPIUM, without valve, *pomum*; containing a *capsule*.

A BERRY, *bacca*; a fleshy or pulpy pericarpium, without valve, the seeds within which have no other covering.

Strobilus, a pericarpium formed of an *amentum* or *catkin*.

OF THE SEED.

THE SEED is the rudiment of a new vegetable. Its distinctions are,

A SEED, *properly so called*, furnished with sap, and covered with a bladdery coat or tunic. It consists of, 1. *corculum*, the origin of a new plant, within the seed. 2. *Plumula*, a scaly part of the corculum; which in vegetation ascends. 3. *Rostellum*, a plain part of the corculum; which in vegetation descends. 4. *Cotyledon*, a side LOBE of the seed, of a porous substance, and perishable. 5. *Hilum*, an external mark or SCAR on the seed, where it was fastened within the fruit. 6. *Arillus*, the proper exterior coat or tunic of the seed; which comes off of itself. 7. *Coronula*, the little crown, of a seed; which is either (a) *calyculus*, the calyx of a floret, adhering to the seed, and assisting it to fly; or (b) *pappus*, a down, a feathery or hairy crown, answering the same

end, and connected with the seed by a *trunk* (stipes) *i. e.* the thread on which the down is supported. 8. *Ala*, a wing, a membrane affixed to the seed, and which by its flying helps to disperse it.

A *NUT*, *nux*; which is a seed, inclosed by a *hard outer coat* (osseous epidermis) *i. e.* the *shell*.

The seed of *MOSS* (*propago*) has neither tunic nor cotyledon, but consists only of the plumula of a naked corculum, where the rostellum is inserted into the calyx of the plant.

OF THE RECEPTACLE.

THE RECEPTACLE is the base which connects the other six parts of fructification. Its appellations are as follow:

1. A *PROPER RECEPTACLE*, that which belongs only to the parts of a single fructification: this is called a *receptacle of the fructification*, when common to both flower and fruit; 2. a *receptacle of the flower*, when it is a base to which the parts of the flower only are fastened, without the germen; 3 a *receptacle of the fruit*, when it is a base for the fruit only, remote from the flower; 4. a *receptacle of the seeds*, when it is a base that fastens the seed within the pericarpium.

A *COMMON RECEPTACLE* is that which connects many florets in such a manner as the taking away any of them would cause an irregularity.

A *CHAFF*, *palea*; is a thin substance, springing from the receptacle to part the florets.

AN *UMBEL*, *umbella*; is a receptacle, which, from a common centre, runs out into thread-shaped foot-stalks, of proportionate lengths. It is, 1. a *simple umbel*, when without subdivisions; 2. a *compound umbel*, when each foot-stalk is terminated by a *little umbel* (*umbellula*); in this case the umbel that bears the *umbellula* on its foot-stalks is called the *universal umbel*; and the *umbellula* which proceeds from it, a *partial umbel*.

A *CYME*, *cyma*, is a receptacle that runs into long fastigate peduncles, *i. e.* their lengths are so proportioned, that the flowers which they support form an even surface, proceeding from the same universal centre, but with irregular partial ones.

SPADIX, is in its primitive sense, the receptacle of a palm, produced within a *sheath* (*spatha*); on the branches that bear fruit.

.....

The *ESSENCE* of a *vegetable* consists in its *fructification*. The essence of the *fructification* consists in the *flower* and *fruit*. The essence of the *flower* consists in the *antheræ* and *stigma*. The essence of the *fruit* consists in the *seeds*.

From these characters the following principles may be deduced:

1. Every

1. Every *vegetable* is furnished with *flower* and *fruit*; there being no species where these are wanting.
2. There is no *fructification* without *antheræ*, *stigma*, and *seed*.
3. The *antheræ* and *stigma* constitute a *flower*, whether the covers are present or wanting.
4. The seed constitutes a *fruit*, whether there be a seed-vessel (*pericarpium*) or not.

In respect to the *seed*, its essence consists in the *corculum*, or new plant.

The essence of the *corculum* consists in the *plumula*; which is the vital speck of the plant itself, extremely small in its dimensions, but increasing, like a bud, to infinity.

OF THE MOST NATURAL STRUCTURE OF THE PARTS OF FRUCTIFICATION.

IN considering the structure of these parts, the principal objects to be attended to are, 1. The *number* of each part. 2. Its *figure*. 3. Its *proportion*, i. e. its height in respect to the rest. 4. Its *situation*; which includes also its *insertion* and *connections*.

The MOST NATURAL STRUCTURE of the parts, in respect to NUMBER, is, to have the *outer bark* (calyx) divided into as many segments as the *inner bark* (corolla); the *threads* (filaments) being equal in number to these segments; a single *summit* (anthera) on each thread; the divisions of the pistillum equal in number to the cells of the receptacle (pericarpium) of the seeds (most commonly *five*); the corolla and calyx also most frequently in *five segments* (quinquifid)

In respect to FIGURE, the most natural structure is, to have the calyx narrower than the corolla; the corolla widening gradually; the stamina and pistillum upright and tapering; the pericarpium big with seeds, swelling and extending after the rest of the parts (the calyx excepted) are fallen off.

In respect to PROPORTION, the most natural structure is, to have the calyx less than the corolla; the pistillum of equal length with the stamina, in an upright flower, but longer in an inverted flower; if the flower slope downward, the stamina and pistillum inclining towards the under side; but if it slope upward, placed close under the upper side.

In respect to SITUATION, the most natural structure is to have the *flower-cup* (perianthium) surrounding the receptacle; the corolla placed on the receptacle, and alternate with the flower-cup; the threads placed within the corolla, but corresponding with the flower-cup; the *antheræ* on the tops of the threads; the germen possessing the centre of the receptacle; the style standing on the top of the germen; and the stigma seated on the top of the style.

When the stigma and style are fallen, the germen, supported by the calyx, and including the seeds which are affixed to the receptacle of the fruit, is greatly enlarged. The receptacle of the flower is generally under that of the fruit.

The calyx, in respect to *number*, is either *single*, *double*, or *wanting*.

In respect to *composition*, it is either, 1. (*Imbricate*) composed of various scales lying over each other. 2. (*Squamose*) composed of scales spreading widely open. 3. (*Auctus*) *augmented*, having a series of distinct leaves, shorter than its own, around its base externally. 4. (*Multiflorus*) *many-flowered*, i. e. common to many florets.

In respect to its *parts*, it is either, 1. *Of one leaf* (monophyllous). 2. *Of two leaves* (biphyllous). 3. *Of three leaves* (triphyllous). 4. *Of four leaves* (tetraphyllous). 5. *Of five leaves* (pentaphyllous). 6. *Of six leaves* (hexaphyllous). 7. *Of ten leaves* (decaphyllous).

In respect to its *segments* (which chiefly concern the monophyllous calyx) it is either *whole* (integer); *divided into two segments* (bifid); *divided into three segments* (trifid); *divided into four segments* (quadrifid); *divided into five segments* (quinquifid); *divided into six segments* (sexfid); *divided into eight segments* (octofid); *divided into ten segments* (decemfid); *divided into twelve segments* (duodecemfid).

The calyx, in respect to *figure*, is either *globe-shaped* (globose); *club-shaped* (clavate); *bent back* (reflex); or *upright* (erect).

It is either *equal*, *unequal*, or with the segments *alternately shorter*.

Its *margin* is either *very entire* (integerrimus); *saw-like* (serrate); or *fringed with hairs like eye-lashes* (ciliate).

Its *top* (apex) is either *sharp* (acute); *pointed* (acuminate); *blunt* (obtusè); or with one of its indents *lopped off*.

It is either *longer* than the corolla, *equal* to it, or *shorter*.

In respect to *SITUATION*, it is either a calyx of the *flower*, of the *fruit*, or of the *fructification*.

In respect to *DURATION*, it is either (caducous) *falling off at the opening of the flower*; (deciduous) *falling off with the corolla*; or *persisting*, till the fruit is come to maturity.

The corolla is either *of one petal* (monopetalous); *of two petals* (bipetalous); *of three petals* (tripetalous); *of four petals* (tetrapetalous); *of five petals* (pentapetalous); *of six petals* (hexapetalous); *of nine petals* (enneapetalous); or *of many petals* (polypetalous).

In respect to its *segments* (laciniae) it has either *two*, *three*, *four* or *five*.

In respect to *figure*, it is either *waved* (undulate); *folded* (plicate); *rolled back* (revolute); or *twisted* (tort).

In

In respect to *equality*, it is either *equal*, *unequal*, *regular*, or *irregular*.

Its *margin* is either *notched* (crenate); *saw-like* (serrate); *fringed* (ciliate); *toothed* or *jagged* between the segments (denticulate); or *hairy*, i. e. its surface.

In respect to *PROPORTION*, it may be *very long*, or *very short*.

The *base* of the corolla is usually close to the *flower-cup* (perianthium) if there be one.

In respect to *DURATION*, it is either *lasting till the fruit is ripe* (persisting); *dropping as soon as the flower is blown* (caducous) *dropping off with the flower* (deciduous) which is the most common; or *withering* (marcescent).

The *FIGURE* of the filaments or threads is either *like hairs* (capillary); *flat* (plane); *wedge-shaped* (cuneiform); *screw-shaped* (spiral); *awl-shaped* (subulate); *notched* (emarginate); *bent back* (reflex); or *hairy* (hirsute).

The *PROPORTION* of the filaments is either *unequal*, *irregular*, *very long*, or *very short*.

The *SITUATION* of the filaments is either *opposite* to the leaves or segments of the calyx, or *alternate* with them. In flowers of one petal, they are inserted into the corolla. *N.B.* In the class *icosandria*, they are always inserted in the calyx, and in some flowers which have no petals; but it is more common for them to be inserted into the *receptacle*.

The *NUMBER* of the antheræ is either *single* to each filament, as is most common; *one to three*; *one to five*; or *two antheræ to each*; *three to each*; *five to three filaments*; or *five to each*.

In some plants that have single antheræ to the filaments, some of the antheræ are often wanting.

The number of cells that contain the pollen, is either *one*, *two*, *three*, or *four*.

The *FIGURE* of the antheræ is either *oblong*; *globose*; *arrow-shaped* (sagitate); *cornered* (angulate); or *horned* (cornute).

They *burst* either on the side, as in most flowers; on the *apex*; or throughout the whole length.

They are *fastened* either by their *base*, as in most plants, their *tops*, their *sides*, or grow to the *nectarium*.

Their *situation* is either on the *tops* of the filaments, as in most plants, on the *sides* of the filaments, on the *pistillum*, or on the *receptacle*.

The *figure* of the particles of the pollen appears, by glasses, to be—a *prickly ball*, as in *helianthus*; *perforate*, as in *geranium*; *double*, as in *symphytum*; *wheel-shaped* and *indented* (rotato-dentate) as in *malva*; *cornered* (angulate) as in *viola*; *kidney-shaped* (reniform) &c.

the

The **STYLE** is divided into two, three, four, or five sections, or is halved, and each half subdivided.

The **FIGURE** of the style is either *cylindrical*; *cornered* (angulate); *awl-shaped* (subulate); *like hairs* (capillary); or *thicker* towards the top,

It is either *very long*, *very short*, or *equal* to the *stamina*.

It is either *thicker* than the *stamina*, *thinner*, or of *equal* thickness.

Its **SITUATION** is either on the *apex* of the *germen*; both *above* and *below* the *germen*; or on the *side* of the *germen*.

The **NUMBER** of the *stigmata* is either *one*, *two*, *three*, *four*, or *five*.

The **pericarpium** is either *absent*; *consisting of one capsule* (unicapsular); *of two* (bicapsular); *of three* (tricapsular); *of four* (quadricapsular); *of five* (quinquecapsular); or *of many*, (multicapsular).

The **fruit**, in respect to the *loculaments*, or internal divisions of the *pericarpium*, is either, *of one cell* (unilocular); *of two* (bilocular); *of three* (trilocular); *of four* (quadrilocular); *of five* (quinquelocular); *of six* (sexlocular); *of eight* (octolocular); *of ten* (decemlocular); or *of many* (multilocular).

The **pericarpium**, in respect to its *valvules*, or outer inclosures, is formed either *of two valves* (bivalve); *of three* (trivalve); *of four* (quadrivalve); or *of five* (quinquevalve.)

All fruit that is *jointed* (articulate) opens at every one of the joints, each of which is *single seeded* (monospermous).

The **situation** of the *pericarpium*, is at the receptacle of the flower, either placed *under* it, as in *vaccinium* and *epilobium*; *over* it, as in *arbutus* and *tulipa*; or both *above* and *below* it, as in *saxifraga* and *lobelia*.

.....

OF THE SEXUAL SYSTEM, AND ITS DIVISIONS.

THE Sexual System was invented by Dr. *Linnaeus*, professor of physic and botany at *Upsal*. The author does not pretend to call it a natural one, he gives it as artificial only.

By the sexual system, plants are disposed according to the number, proportion, and situation of their *stamina* and *pistilla*.

The first general division of the whole body of vegetables is into twenty-four *classes*; these are subdivided into *orders*, the orders into *genera*, the genera into *species*, and the species into *varieties* where there are any worthy of note; but we do not mean to pursue these divisions beyond the principles of the orders.

TABLE

TABLE OF THE CLASSES AND ORDERS.

CLASSES.	ORDERS.
1. MONANDRIA	1. <i>Monogynia</i> . 2. <i>Digynia</i> .
2. DIANDRIA	{ 1. <i>Monogynia</i> . 2. <i>Digynia</i> . 3. <i>Trigynia</i> .
3. TRIANDRIA	{ 1. <i>Monogynia</i> . 2. <i>Digynia</i> . 3. <i>Trigynia</i> .
4. TETRANDRIA	{ 1. <i>Monogynia</i> . 2. <i>Digynia</i> . 3. <i>Tetragynia</i> .
5. PENTANDRIA	{ 1. <i>Monogynia</i> . 2. <i>Digynia</i> . 3. <i>Trigynia</i> . 4. <i>Tetragynia</i> . 5. <i>Pentagynia</i> . 6. <i>Polygynia</i> .
6. HEXANDRIA	{ 1. <i>Monogynia</i> . 2. <i>Digynia</i> . 3. <i>Trigynia</i> . 4. <i>Tetragynia</i> . 5. <i>Polygynia</i> .
7. HEPTANDRIA	{ 1. <i>Monogynia</i> . 2. <i>Digynia</i> . 3. <i>Tetragynia</i> . 4. <i>Heptagynia</i> .
8. OCTANDRIA	{ 1. <i>Monogynia</i> . 2. <i>Digynia</i> . 3. <i>Trigynia</i> . 4. <i>Tetragynia</i> .
9. ENNEANDRIA	{ 1. <i>Monogynia</i> . 2. <i>Trigynia</i> . 3. <i>Hexagynia</i> .
10. DECANDRIA	{ 1. <i>Monogynia</i> . 2. <i>Digynia</i> . 3. <i>Trigynia</i> . 4. <i>Pentagynia</i> . 5. <i>Decagynia</i> .
11. DODECANDRIA	{ 1. <i>Monogynia</i> . 2. <i>Digynia</i> . 3. <i>Trigynia</i> . 4. <i>Pentagynia</i> . 5. <i>Dodecagynia</i> .
12. ICOSANDRIA	{ 1. <i>Monogynia</i> . 2. <i>Digynia</i> . 3. <i>Trigynia</i> . 4. <i>Pentagynia</i> . 5. <i>Polygynia</i> .
13. POLYANDRIA	{ 1. <i>Monogynia</i> . 2. <i>Digynia</i> . 3. <i>Trigynia</i> . 4. <i>Tetragynia</i> . 5. <i>Pentagynia</i> . 6. <i>Hexa-</i> <i>gynia</i> . 7. <i>Polygynia</i> .
14. DIDYNAMIA	{ 1. <i>Gymnospermia</i> . 2. <i>Angios-</i> <i>permia</i> .
Part IV. No. 25.	H 15. TETRADYNAMIA.

CLASSES.	ORDERS.
15. TETRADYNAMIA	1. <i>Siliculosa</i> . 2. <i>Siliquosa</i> .
16. MONADELPHIA	{ 1. <i>Pentandria</i> . 2. <i>Decandria</i> . 3. <i>Endecandria</i> . 4. <i>Dodecandria</i> . 5. <i>Polycandria</i> .
17. DIADELPHIA	{ 1. <i>Pentandria</i> . 2. <i>Hexandria</i> . 3. <i>Octandria</i> . 4. <i>Decandria</i> .
18. POLYADELPHIA	{ 1. <i>Pentandria</i> . 2. <i>Icosandria</i> . 3. <i>Polycandria</i> .
19. SYNGENESIA	{ 1. <i>Polygamia æqualis</i> . 2. <i>Polygamia superflua</i> . 3. <i>Polygamia frustranea</i> . 4. <i>Polygamia necessaria</i> . 5. <i>Polygamia segregata</i> . 6. <i>Mono-gamia</i> .
20. GYNANDRIA	{ 1. <i>Diandria</i> . 2. <i>Triandria</i> . 3. <i>Tetrandria</i> . 4. <i>Pentan-dria</i> . 5. <i>Hexandria</i> . 6. <i>De-candria</i> . 7. <i>Dodecandria</i> . 8. <i>Polycandria</i> .
21. MONOECIA	{ 1. <i>Monandria</i> . 2. <i>Diandria</i> . 3. <i>Triandria</i> . 4. <i>Tetan-dria</i> . 5. <i>Pentandria</i> . 6. <i>Hexandria</i> . 7. <i>Heptandria</i> . 8. <i>Polyandria</i> . 9. <i>Monadelphia</i> . 10. <i>Syngenesia</i> . 11. <i>Gynandria</i> .
22. DIOECIA	{ 1. <i>Monandria</i> . 2. <i>Diandria</i> . 3. <i>Triandria</i> . 4. <i>Tetran-dria</i> . 5. <i>Pentandria</i> . 6. <i>Hexandria</i> . 7. <i>Octandria</i> . 8. <i>Enneandria</i> . 9. <i>De-candria</i> . 10. <i>Dodecandria</i> . 11. <i>Polycandria</i> . 12. <i>Monadelphia</i> . 13. <i>Syngenesia</i> . 14. <i>Gynandria</i> .
23. POLYGAMIA	{ 1. <i>Monoecia</i> . 2. <i>Dioecia</i> . 3. <i>Trioecia</i> .
24. CRYPTOGAMIA	{ 1. <i>Filices</i> . 2. <i>Musci</i> . 3. <i>Algæ</i> . 4. <i>Fungi</i> .
APPENDIX	1. <i>Palma</i> .

REMARKS ON THE CLASSES.

THE first ten classes, which consist of hermaphrodite flowers, take their denominations from the number of stamina, *i. e.* from one to ten. It must be observed, however, that the flowers being hermaphrodite, is in all these classes a necessary condition; for should the pistillum be wanting, the plant would belong to some other class, notwithstanding the number of stamina may be such as would otherwise refer it to one of these.

In CLASS XI the flowers have *twelve* stamina; but this class includes all such hermaphrodite flowers as have from *twelve* to *nineteen* stamina. No flowers have been yet found to have eleven stamina.

In CLASS XII the flowers have *twenty* stamina, often more.

In CLASS XIII the flowers have *many* stamina.

In CLASS XIV the flowers have four stamina, of which two are longer than the other two.

In CLASS XV the flowers have six stamina, of which four are longer than the other two.

In CLASS XVI the term *brother* (MONADELPHIA) is employed to express the union of the filaments of the stamina, which in this class join at the base, and form one substance, out of which they proceed; this class has only a *single* brotherhood, or *one* set of stamina so united, which distinguishes it from the following.

CLASS XVII has *two* sets of stamina, united in the manner of the preceding.

CLASS XVIII has *many* brotherhoods, or sets of stamina.

In CLASS XIX the antheræ are united in a cylinder, and perform their office *together*.

In CLASS XX the flowers of the stamina grow upon the pistillum; so that the male and female parts are united.

In CLASS XXI the term *monoecia* signifies a *single* house; in this class, the male and female flowers are both found on the *same* plant.

CLASS XXII. DIOECIA.—This term, which signifies *two* houses, expresses the circumstance of the *male* flowers being on one plant, and the *female* on another.

CLASS XXIII produces either the same or different plants, *hermaphrodite* flowers, and also flowers of *one* sex only, male or female; or flowers of *each* sex; the latter receiving impregnation from, or giving it to the hermaphrodites.

CLASS XXIV. CRYPTOGRAMIA.—The term signifies *concealment of marriages*; this class consisting of such plants as either bear their flowers concealed within the fruit, or have them so small as to be imperceptible.

REMARKS ON THE ORDERS.

THE orders of the first thirteen classes take their denominations from the number of the *pistillum*, or female part of the plant, which is usually reckoned from the *base* of the *style*, if there be any; but if the style be wanting, the number is fixed from the *stigmata*. *Monogynia* implies *one* style; *digynia*, *two* styles; *trigynia*, *three*; *tetragynia*, *four*; *pentagynia*, *five*; *hexagynia*, *six*; *decagynia*, *ten*; and *polygynia*, *many* styles.

CLASS XIV. DIDYNAMIA.—Of the three orders of this class the two first have a distinction in the fruit. *Gymnospermia* signifies *naked* seeds; *angiospermia* inclosed seeds. The third order, *polypetala*, signifies *many* petals.

CLASS XV. TETRADYNAMIA.—The two orders of this class have a distinction in the *pericarpium*. In the *siliculosa*, the *pericarpium* is a *little siliqua*, a round pod or cod. In the second order, the *siliqua* is a long pod.

CLASS XVI. MONADELPHIA. XVII. DIADELPHIA. XVIII. POLYADELPHIA. These three classes are distinguished by the number of the *stamina* in each brotherhood or distinct set.

CLASS XIX. SYNGENESIA. *Polygamy* in flowers, alludes to the intercommunication of the male or female flowers with the hermaphrodite ones, either upon the same or a distinct plant. But the term is applied to a single flower only; for the flowers of this class being compound, a polygamy arises from the intercommunication of the several florets in one and the same flower. This is the foundation of the four first orders of this class. 1st, *Equal polygamy*, when *all* the florets are *hermaphrodite*. 2d, *Superfluous polygamy*, when *some* of the florets are *hermaphrodite*, and *others* *female* only; for as the fructification is perfected in the hermaphrodites, the addition of the females is superfluous. 3d, *Frustraneous polygamy*, when some of the florets are *hermaphrodite*, and others *neuter*; the addition of the neuters being of no assistance to the fructification. 4th, *Necessary polygamy*, when some of the florets are *male*, and the rest *female*. 5th, *Polygamia segregated*, i. e. separated, the plants of this order having partial cups growing out of the common calyx, which surround and divide the florets. 6th, *Monogamous polygamia*; in this order, though the
antheræ

antheræ are united, which is the essential character of the flowers of this class, the flower is *simple*, and not compounded of many florets.

CLASS XX. GYNANDRIA. The orders of this class are founded on the number of stamina.

CLASS XXI. MONOECIA. Same residence.

CLASS XXII. DIOECIA. Separate residences. Of these two classes, the flowers have no fixed character, but that of not being hermaphrodite.

CLASS XXIII. POLYGAMIA. In this class the titles of the two first orders are the same with the titles of the twenty-first and twenty-second classes, and are to be understood in the same manner; that is, 1. *monoecia*, when the polygamy is on the *same* plant; and 2. *dioecia*, when it is on *distinct* plants. The order *trioecia* has been established in favour of a single genus, the *fig*; in which the polygamy is on *three* distinct plants, one producing male flowers, another female, and a third hermaphrodite, or androgynous.

CLASS XXIV. CRYPTOGAMIA, *Secret-seeded*; the orders of this class are, 1. *ferns*, filice; 2. *mosses*, musci; 3. *slugs*, algæ; and, 4. *mushrooms*, fungi.

PALMÆ, comprehending such plants as have a *spadix*, and *spatha*.

GENERAL PRINCIPLES.

THE fructification being admitted as the only foundation of the generic distinctions, all vegetables that *agree* in their parts of fructification are to be put together under one genus; and all such as *differ* in those parts are to be separated.

There is, however, no one part of fructification that can be relied on as a constant characteristic mark for all genera; it being found, that the part which is constant in some genera will be inconstant in others.

When the characteristic mark of any genus is wanting in any particular species, we should proceed with caution, lest we confound genera that should be distinguished.

When the characteristic mark of any genus is observed in some species of another genus near of kin to it, a like caution is again necessary, on the other hand, lest we should multiply the genera by parting species that should stand together.

THE
BOTANICAL PRECEPTOR.

PART IV.

BEING A SPECIMEN OF THE HISTORY OF
REMARK-ABLE VEGETABLES.

Of Plants yielding Food.

THE CABBAGE-TREE.

THE CABBAGE-TREE, OR MOUNTAIN-PALM, the *palma altissima non spinosa* of Sloane, is a native of the West-Indies, where it is said to rise to the height of one hundred and fifty, and two hundred feet. It is by some authors called the palmetto royal; and well, says Hughes, in his "Natural History of Barbadoes," may it be called *royal*, since neither the tall cedars of Lebanon nor any of the trees of the forest, are equal to it in height, beauty, or proportion. It is generally as straight as an arrow; near the earth it is about seven feet in circumference, but tapers as it ascends. The bark is of an ash colour till within twenty-five or thirty feet of the extremity of the tree, when it alters at once to a deep sea-green, which continues to the top. Upon removing the large leaves, or branches, which surround the top of the trunk a little way above the beginning of the green bark just mentioned, what is called the cabbage is discovered, lying in many thin, snow-white, brittle flakes, in taste resembling an almond, but sweeter. This substance, which cannot be procured without destroying the tree, is boiled, and eat with mutton, by the inhabitants of the West Indies, in the same manner as turnips and cabbages are with us; it is likewise pickled, and sent to Europe, where it is esteemed an exquisite delicacy.

In the pith of the trunk of the cabbage-palms, when felled, there breeds a kind of worms, or grubs, which are eaten, and esteemed a great delicacy by the French of Martinico, St. Domingo, and the adjoining islands. These worms, says Father Labat, are about two inches long, and of the thickness of one's finger; the head is black, and attached to the body without any distinction of neck. Their preparation for the table is as follows: they are strung on wooden skewers before a fire, and as soon

soon as heated, rubbed over with raspins of crust, salt, pepper, and nutmeg; this powder absorbs all the fat, which during the cookery, would otherwise escape; when properly roasted, they are served up with orange or citron sauce. These worms being exposed for some time to the sun, are said to yield an oil which is of great efficacy in the piles. The oil in question, says Labat, is never to be heated before its application to the part affected; as repeated experiments have evinced that its spirit is totally dissipated by the fire.

S A G O.

From the pith of a species of palm that grows naturally in Japan, is prepared the substance well known in shops by the name of *sago*. The pith is taken out, and after being pounded in large mortars, is mixed with water. The liquor is then strained, and the *fæculæ* formed into cakes, which the Japanese eat as bread, in default of rice: part of the same substance they granulate and dry, and send into Europe by the name of *sago*; it is esteemed highly nourishing and restorative.

P A L M S.

The DATE-TREE, the *phœnix dactylifera* of Linnæus, is a native of Africa, and the eastern countries, where it grows to fifty, sixty, and one hundred feet high. The trunk is round, upright, and studded with protuberances, which are the vestiges of the decayed leaves. From the top issues a cluster of leaves or branches, eight or nine feet long, extending all round like an umbrella, and bending a little towards the earth. The bottom part produces a number of stalks like those of the middle, but seldom shooting so high as four or five feet. These stalks, says Adanson, diffuse the tree very considerably; so that, wherever it naturally grows in forests, it is extremely difficult to open a passage through its prickly leaves. The flowers are male and female upon different roots. The dates, which are the produce of the female plant, grow in large spiral clusters, each being about the bigness and shape of a middling olive, and containing within the pulp, which is of a yellow colour, and agreeable taste, a round, strong, hard nut or stone, of an ash-colour, marked with a deep furrow, running length-wise. Of the fresh dates and sugar, says Hasselquist, the Egyptians make a conserve, which has a very pleasant taste. The kernels or stones, though hard as horn, they grind on hand-mills, and in default of better food, give to their camels. Of the leaves are made baskets, or bags, which are much used in Turkey on journies, and
for

for other œconomical uses. In Egypt they are used as fly-flaps for driving away the numerous insects, which prove so troublesome in hot countries; and Rauwolf relates that of the fibres of the leaves, and covering of the fruit, are spun ropes, of pretty large dimensions, and considerable strength; the harder boughs are used for fences, and other purposes of husbandry; the principal stem for building; in fine, no part of this curious tree wants its use. The fruit, before it is ripe, is somewhat astringent, but when thoroughly mature, is of the nature of the fig. The Senegal dates are shorter than those of Egypt, but much thicker in the pulp, which is said to have a sugary agreeable taste, superior to that of the best dates of the Levant.

PALMETTO, *i. e.* LITTLE PALM, called by the Americans, *thatch*, from the use to which the leaves are applied, is a native of Africa and the West-Indies, and seldom grows so high as the other palms. Mr. Adanson, however, describes, under the name of palmetto, a species of palm, which grows naturally at Senegal, whose trunk rises from fifty to sixty feet in height. The negroes call this palm *ronn*, which name the French have changed to *rondier*: from the upper end of the trunk issues a bundle of leaves, which in turning off form a round head; each leaf represents a fan of five or six feet in expansion, supported by a tail of the same length. Of these trees some produce male flowers, which are consequently barren; others are female, and loaded with fruit, which succeed each other uninterruptedly almost the whole year round. The fruit of the large palmetto, Mr. Adanson affirms to be of the bigness of an ordinary melon, but rounder; it is enveloped in two skins, as tough as leather, and thick as strong parchment; within the fruit is yellowish, and full of filaments, fastened to three large kernels, in the middle. The negroes are very fond of this fruit, which when baked under the ashes, is said to taste like a quince.

PALM-OIL-TREE, or OILY PALM, is a native of Africa, and rises about fifty-feet high; from the fruit is drawn an oil, of which the negroes are remarkably fond. They generally roast the fruit in the embers, and then suck the fine sweet oil, which is contained in the many interstices of its yellow husky tegument, or covering; with this oil they likewise anoint their bodies, to prevent a too plentiful perspiration, as well as to supple and relax their stiffened nerves; being thus anointed, their skins appear sleek and shining. Within the outward covering is the nut, which contains a white kernel, in taste somewhat resembling that of a cocoa-nut, but not so agreeable. These nuts, when bored and emptied of their kernels, are strung by the negroes as ornaments, about their necks. From the body of this and the cocoa-nut-tree is extracted a liquor, which when fermented

mented, has an intoxicating quality, and is known by the name of palm-wine.

C O C O A - P A L M.

THE COCOA-NUT-TREE is supposed to be a native of the Maldiv Islands, but is cultivated in both Indies, particularly in South-America, and the West-India Islands, where it supplies the inhabitants with many of the common necessities of life. This tree frequently rises sixty feet high. The body of the trunk, which generally leans to one side, occasioned, as is supposed, by the great weight of nuts which it sustains when young, is the exact shape of an apothecary's large iron pestle, being of an equal thickness at top and bottom, but somewhat smaller in the middle; its colour is of a pale brown throughout, and the bark smooth. The leaves or branches, often fifteen feet long are about twenty-eight in number, winged, of a yellow colour, straight and tapering. The pinnae, or partial leaves, are green, often three feet long next the trunk, but diminishing in length toward the extremity of the branches. The branches are fastened at bottom by brown stringy threads, about the size of ordinary packthread, that grow out of them, and are interwoven like a web. The nuts hang at the top of the trunk, in clusters, of a dozen each. Each nut, next the stem, has three holes, closely stopped; one of them being wider, and more easily penetrated than the rest. When the kernel begins to grow, it incrusts the inside of the nut in a bluish jelly-like substance; as this grows harder, the inclosed liquid, distilled into the nut from the roots, becomes somewhat acid; and the kernel itself, as the nut ripens, becomes still more solid; and, at length lines the whole inside of the nut for above a quarter of an inch thick, being as white as snow, and of the flavour of an almond. The quantity of liquor in a full-grown nut is frequently a pint, and upwards. The husky tegument of the nut consists of strong, tough stringy filaments, which when removed from the fruit, resemble coarse oakum; and may perhaps be conveniently enough used as such. The shells of these nuts, being tipped with silver, are frequently used for drinking bowls; the bark of the tree may be wrought into cordage, and the leaves into baskets, brooms, hammocks; in form of nets, mats, sacks, and other useful utensils. The liquor contained in the shell is a most cooling wholesome beverage in those sultry climates, and the white kernel a most agreeable food.

BOTTLE - GOURD.

IN the eastern countries, and both the Indies, BOTTLE-GOURDS, the *cucurbita lagenaria*, of Linnæus, are very commonly cultivated, and sold in the markets, for the table, and are the principal part of the food of the common people, in the warm months, particularly from June to October. The Arabians call this kind of gourd, *charrah*. They boil it and season it with vinegar; they likewise fill the shell with rice and meat, and thus make a kind of pudding, like what we sometimes in England prepare of the shell of pompions, or pumpkins.

The leaves of the bottle-gourd are large and almost circular, covered with fine soft hairy down, and smell strongly of musk. The flowers are so tender, that they close as soon as the sun shines upon them. The outside tegument, or rind of the fruit, as it ripens, grows hard; and when the seeds and pulp are taken out, will hold water, for which purpose it is sometimes used. Some gourds are six feet long, and one and a half round, and when cleared of their pulp, will contain twenty-two gallons: such, however, are very uncommon.

WATER - MELON.

WATER-MELONS, or CITRUILS, the *Anguria* of Tournefort, the *cucurbita citrullus* of Linnæus, are distinguished, by the colour of their pulp, into the white and red; and derive their name from the great quantity of water, or liquid, which they contain. These fruits, by their cooling and diuretic quality, are beneficial in hot climates, if used in moderation: the poor people in Persia and the Levant live almost solely, during the hot months, upon the musk and water-melons, cucumbers, and milk. The water-melon, says Hasselquist, serves the Egyptians for meat, drink, and physic: when it is very ripe, and almost putrid, they hollow part of it, gather the juice there collected, and mixing it with rose-water, and a little sugar, administer it in burning fevers, with such success, that the common people use no other medicine in those distempers. It is not, however, from the common water-melon that this medicine is procured. The fruit in question is softer, more juicy, and more rarely to be found than the common sort, of which this is a variety. It is termed by the Arabs, *et-narwi*, which signifies water.

Water-melons should be eaten with great circumspection; for if taken in the heat of the day, when the body is very warm, they seldom fail to occasion colics, fluxes, and disorders of the stomach.

The

The common cucumber, in the eastern countries, is boiled and eaten with vinegar. The richer sort fill it with flesh and spices, and bake it into a pudding, which is said to be extremely palatable.

PINE-APPLE.

If the judgment of the most numerous part of mankind, who have tasted of the PINE-APPLE, may be relied on, it certainly deserves the appellation it has universally obtained, that of king of fruits; the agreeable variety, and delicate quick poignancy of its juice, is justly esteemed to excel every other. The roots are many, and spread in a circular manner. From the centre rises a strong, hard stalk, surrounded, near the earth, and for a considerable way up the stalk, with long green leaves, which are set on alternately, and finely sawed on their edges. The top of the stalk sustains the fruit, which is called the pine, from some resemblance which it has on the outside to the cone of the pine-tree. The fruit is beautifully decorated at top, with a crown of fine green sharp-pointed leaves, which are likewise sawed on their edges. The flowers are funnel-shaped, placed above the fruit, of a blue colour, and consist of three petals. When the flowers are gone, the fruit enlarges and becomes a fleshy, knobby seed-vessel, of the berry kind; full of juice. The seeds, which are lodged in the knobs, or tubercles of the fruit, are very small, and almost kidney-shaped. Some time before the fruit is ripe, two, three, or four suckers grow from the stalk below, yet close to the fruit: these shoots are taken off, and planted; and will in about fourteen months' time produce a ripe pine. Those who cannot procure these suckers, sometimes plant the top, or crown. This, though intended by Nature chiefly as an ornament to the fruit, will grow, and in time bear a fruit; not so soon, however, nor so good as that produced by those suckers which Nature intended to be the means of propagating this fruit. The three best sorts of pines, are the Surinam, the sugar-loaf, and queen-pine. The fruit ought to be eaten soon after it is cut, and should not be kept on the stalk in the garden till it be very soft on the outside, as the custom too frequently is.

To the same genus with the pine-apple, belongs the KARATAS, or PENGUIN a fruit very common in the West-Indies, so named from its outward covering, which is a smooth whitish-yellow husk. The outside of the plant is composed of some scores of hard stiff green leaves, two inches broad, with sharp hooked prickly edges. These leaves which grow to about nine feet high, turn scoopingly inward, on the upper side, by which

means they save and convey the dew and the rain that fall upon them, to the roots. They grow, likewise, almost impenetrably thick near the earth, surrounding and guarding a circular crown, of about a foot diameter. From this grows a cluster of fruits, each four inches long, and one broad, pointed at both ends, and quadrangular in the middle; by which means they are so closely joined, that they cannot easily, until very ripe, be taken asunder. The white outward cover being peeled off, displays a white pulpy substance, containing a great number of very small flat-tish coal-black seeds. This substance, which is the eatable part, has some small resemblance, in its flavour, to the pine-apple, and is esteemed cooling and wholesome. This fruit, when nearly ripe, being gnawed by rats, or other vermin, emits from the wounded part drops of the most transparent gum, which manifestly shows, that its juices are much impregnated with volatile oil. A moderate use of this fruit has been very strongly recommended in fevers, and with justice; for by its penetrating, grateful, and active sharpness, it is capable of laying open the orifices of the salival ducts, and thereby enabling the glands of the mouth and throat to discharge their contents, which could not be done before the impediment was removed.

Besides this sort, there is a large and round penguin, of the size of an apple, which is much more palatable than the other, and tasting not unlike a strawberry, is frequently called by that name.

C A R A G U A T A.

TILLANDSIA, the CARAGUATA of Father Plumier, the large wild barren pine of the West-Indians, is a parasitic plant, and ought, perhaps, in strict propriety, to be denominated an aquatic: for although it is suspended in the air among the branches of lofty trees, to whose boughs it is fastened by its numerous roots; yet it is not indebted to those boughs, like the mistletoe, and other parasitic plants, for nourishment, but merely for support: provident Nature having, in a very extraordinary manner, supplied this with other means to preserve its existence; for the leaves, which much resemble those of the pine-apple, but are larger, surround this plant in a circular manner: each leaf being terminated near the stalk, with a hollow bucket, which contains about half a pint of water. It is by these numerous small reservoirs of water, that the roots, as well as every other part of this plant, are supplied with nourishment, without the help of any earth. The flourishing condition of this plant, as well as the great growth of fig-trees, upon barren rocks, shows that water is of greater use to vegetation, than earth.

One

One contrivance of Nature, in this vegetable, says Dr. Sloane, is truly admirable. The seed is crowned with many long downy threads, not only that it may be carried every where by the wind; but that, by those threads, when driven through the boughs, it may be held fast, and stick to the arms, and prominent parts of the barks of trees. So soon as it sprouts, or germinates, although it be on the under part of a bough, its leaves and stalk rise perpendicular, or erect; if they assumed any other direction, the cistern, or reservoir, just mentioned, made of the hollow leaves, could not hold water, which is necessary to the life and nourishment of the plant. In scarcity of water, this reservoir is useful not to the plant only, but to men, and even to birds, and all sorts of insects, which come thither in troops, and seldom go away without refreshment.

To the same purpose, Dampier, in his voyage to Campeachy, relates, that the wild pine has leaves that will hold a pint and a half, or a quart, of rain-water, which refreshes the leaves and nourishes the roots. "When we find these pines," he continues, "we stick our knives into the leaves, just above the root; and the water gushing out, we catch it in our hats, as I myself have frequently done, to my great relief."

SUGAR - CANE.

The SUGAR-CANE grows naturally in both Indies, where it is likewise cultivated for its juice; which when boiled, affords that sweet substance called sugar.

In the manner of their growth, form of their leaves, and make of their panicle, the sugar-canes resemble the reeds which grow in wet marshy grounds in England, or elsewhere, except that the canes are far larger, and instead of being hollow, as the reeds, are filled with a white pith, containing the sweet juice or liquid which stamps such an amazing value upon these plants. The intermediate distance between each joint of a cane is of different lengths, according to the nature of the soil, richness of the manure, and temperature of the weather during its growth; it seldom exceeds, however, four inches in length, and an inch in diameter. The length of the whole cane likewise depends upon the above circumstances. It generally grows to perfection in about fourteen months, when its height, at a medium, is about six feet, sometimes more and sometimes less. The body of the cane is strong, but brittle; of a fine straw-colour, inclining to yellow. The extremity of each is covered, for a considerable length, with many long grassy leaves or blades, sharply and finely sawed on their edges; the middle longitudinal rib being high and prominent.

The

The bottom part of the sugar-cane top is about the bigness of one's finger; and as it contains a good deal of the natural sweetness of the plant, it is usually cut into pieces of an inch and a half long, and given to the saddle horses in the West-Indies. It is very nourishing food, and fattens them apace. The mill-horses, mules and asses, are likewise fed, during crop-time, on sugar-cane-tops, and the scumming of the sugar-coppers; which last must be administered sparingly at first, for fear of griping, and perhaps killing them.

The canes, when ripe, are squeezed between the iron-cased rollers of wind-mills, or cattle-mills. The juice, thus pressed out, is boiled first in a very large copper or cauldron, being mixed with a very small quantity of lime. In default of lime, a strong ley of ashes will answer the same purpose, and was indeed originally used, though the first is generally thought to have the greater efficacy. The benefits arising from either substance, are probably to be attributed, in a great measure, to their alkaline qualities. The sugar-cane, when ripe, is, of all plants, the sweetest; there is however, a latent acid still lurking in the juice; as is manifest by its turning sour if suffered to remain unboiled any considerable time after expression. The addition therefore, of white lime, which the planters call *temper*, is necessary to destroy, in a great measure, the remaining acid, and to form a neutral salt.

Lime, or the strong ley just mentioned, likewise serves to carry off all impurities from the liquor. When the quantity of *temper* is duly proportioned, if the liquor is put into a glass, an immediate separation will follow; the drosses settle at the bottom; the juice remains transparent at the top. On the other hand, if there is a deficiency of *temper*, the separation will be imperfect; and if there is a superfluity, there will be no separation at all.

After the lime is mixed with the juice in the copper or cauldron, the impurities in question being no longer intimately united with the boiling liquor, and being forced about with the heat of the fire, are easily entangled in a viscous tough substance, naturally in the cane-juice, with which they rise to the top of the copper, forming a thick tough scum.

The clarification of the liquor, as far as is done in the first copper, is perfected after the more gross scum is taken off; the remaining impurity, as the liquor boils, is scummed off from the four or five remaining coppers, into which the liquor is successively poured; each of the coppers being gradually less, as containing a less quantity of liquor.

In its passage to the fourth copper, the liquor is strained through a thick woollen cloth, where it leaves all the remaining impurities that had escaped the scummer.

After

After this a light white scum is taken off; and, when this ceases to arise in any considerable quantity, and the liquor, by long boiling, becomes more of a syrup than a thin liquid, it is then poured into the first tache, and from this to a lesser, till it is conveyed to the last. When it has here attained the due consistence necessary to become sugar, it may be asserted, says Hughes, from whom this account is chiefly extracted, that no more than a seventh part of the whole remains; which diminution is occasioned by the impurities being scummed off, and the watery particles evaporated.

From this last stage it is conveyed, while of the consistency of a thick granulated syrup, into a large brass cooler, where it shoots into crystals, which are the genuine and essential salts of the plant; these are forwarded by gently stirring the whole mass, by which means the air is admitted to every part, and the particles of sugar disengage themselves from the clammy substance which is termed melasses.

When it has grained or crystalized, it is removed from the cooler into pots, or moulds, which are earthen, and of a pyramidal form, containing from eight to thirteen gallons.

About twenty-four hours after the sugar is potted, the small round hole in the bottom of each pot is unstopped, and the pots put upon earthen jars, containing about four gallons each: into these vessels, the melasses drain from the sugar; which in this degree of perfection, is called muscovado, and is fit for exportation in a month, or sooner.

From the above-mentioned scummings, mixed with a quantity of water and melasses, and fermented, is extracted that spirituous liquor called RUM; and from the great quantity of oil in the cane-juice, which is transmitted in abundance to the rum, proceeds the excellency of that spirit, compared with brandy. The latter wanting this oiliness, stimulates and lacerates the coats of the stomach; whereas the former, if meliorated by age, and drank moderately, serves, by its oiliness, to lubricate and preserve the bowels.

The most natural, and perhaps the only proper method of producing canes, is by suckers, or with the tender tops of old canes. These being cut into pieces of about a foot long, planted in holes of about six inches deep, and two feet wide, and covered with good manure, each piece will produce from its roots a great number of canes.

R I C E.

RICE is greatly esteemed in most of the eastern countries, where it is the chief support of the inhabitants. The plant bears

stalk about three or four feet high, much stronger and thicker than that of wheat or other corn. The leaves are long, like the reed, and fleshy; the flowers blow on the top, like barley; but the seed which follows is disposed in clusters, each of which is enclosed in a yellow husk, ending in a spiral thread. The seed is oblong, or rather oval and white. The plant is cultivated in moist or low grounds in Italy, and the seed brought dry from Piedmont, Spain, and several other places.

Besides the other uses of rice, both for food and physic, there is an excellent spirituous liquor made from it, which the people of Peru call *acua*, and we, from a wrong pronounciation of the word, arrack.

Rice is the chief commodity and riches of Damiata, in Egypt. Dr. Hasselquist thus describes the manner in which they dress and decorticate, that is, separate it from the husk. It is pounded by hollow iron pestles, of a cylindric form, an inch in diameter, lifted up by a wheel worked by oxen. A person sitting between the two pestles, pushes forward the rice, when the pestles are rising; another sifts, winnows, and lays it under the pestles. In this manner they continue working it, until it is entirely free from chaff and husks. When clean, they add a thirtieth part of salt, and pound them together; by which the rice, formerly grey, becomes white. After this fining, it is passed through a fine sieve, to part the salt from the rice; and then it is ready for sale. Damiata sells every year sixty thousand sacks of rice, the greatest part of which goes to Turkey. Some to Leghorn, Marseilles, and Venice.

GUINEA - CORN.

GUINEA-CORN is the *milium arundinaceum* of Caspar Bauhin, the *holcus sorghum* of Linnæus. The stalks are large and compact, and full eight feet high. In Senegal, the fields are entirely covered with it. The negroes, who call it *guiarrot*, cover the ears, when ripe, with its own leaves, to shelter it from the sparrows, which are very mischievous in that country. The grain, made into bread, or otherwise used, is esteemed very wholesome. It is with this that the slaves in the West Indies are generally fed, each being allowed from a pint to a quart every day. The juice of the stalks is so agreeably luscious, that if prepared as the sugar-cane, they would afford an excellent sugar. The Negroes on the coast of Guinea, make of two sorts of millet, a thick grained pap, called *couscous*, which is their common food.

TEA-

TEA-PLANT.

THIS shrub, formerly described by Dr. Breynius, in his "Century of Exotic Plants," published at Dantzick, in 1678, is of a very slow growth, and diminutive size. It has a black, woody, irregularly branched root. The rising stem soon spreads into many irregular branches and twigs. These, at the lower end, and near the ground, often seem to be more in number than they really are; for several seeds being put together in one hole, it frequently happens, that two, three, or more shrubs grow up together, and so close to one another, as to be easily mistaken for one, by ignorant, or less attentive observers. The bark is dry, thin, weak chestnut-coloured, firm, and adheres closely to the wood. It is covered with a thin skin, which being removed, the bark appears, of a greenish colour, bitter, nauseous, and astringent taste, with a smell much like the leaves of hazel-nut-tree, only more disagreeable and offensive. The wood is hard, fibrous, of a greenish colour, inclining to white, and of a very offensive smell, when green. The pith is very small, and adheres close to the wood. The branches and twigs are slender, of different sizes, irregularly beset with simple leaves, standing on very small, fat, green foot-stalks, and resembling, when full grown, the leaves of the garden cherry-tree; but when young, tender, and gathered for use, those of the common spindle-tree, the colour only excepted. The leaves are smooth on both sides, closely and unequally sawed on the edge, of a dirty dark-green colour, which is somewhat lighter on the back, where the nerves being raised considerably, leave so many hollows, or furrows on the opposite side. They have one very conspicuous nerve in the middle, which is branched out on each side into five, six, or seven thin transverse ribs, of different lengths, and bent backwards, near the edges of the leaves; between these transverse ribs, runs a number of small veins. The leaves, when fresh, have no smell at all, and though astringent and bitterish, as observed above, are not nauseous, as the bark. They differ very much in substance, size, and shape, according to their age, and the situation and nature of the soil in which the shrub is planted. From the wings of the leaves come forth the flowers in autumn. These continue to grow till late in winter, and are composed of six petals, one or two of which are generally shrunk, and fall far short of the largeness and beauty of the others. The foot-stalk of the flower is about half an inch long, and ends in six very small green leaves, which serve instead of the calyx, or flower-cup. This description, applied by Kæmpfer to the

shrub which, as he pretends, produces all the different sorts, or preparations of tea, corresponds, says Linnæus, to a particular species only, termed by him *Bohea*; for some tea-plants, he observes, after Dr. Hill, produce flowers composed of nine petals, which must therefore constitute a distinct species from such as have only six. From this circumstance is constructed the other species of that author, *thea viridis*, or green tea, the flowers of which have always nine petals.

To proceed in our description. Within the petals, which are of a very unpleasant bitterish taste, are placed many white stamina, exceedingly small, as in the wild rose, with yellow heads, in shape not unlike a heart. Kæmpfer reckoned in one flower, two hundred and thirty of these stamina. To these flowers succeed the fruits, in great plenty; these are composed of one, two, but most commonly of three capsules, of the bigness of wild-plums, adhering, like the seed-vessels of the palma-christi, to one common foot-stalk, as to a centre, but divided into three pretty deep partitions. The striking circumstance of its tri-capsular fruits seem naturally to point out its connection and affinity with those plants which possess the same remarkable character. Each capsule contains a husk, nut, and seed. The kernel, or seed, is reddish, of a firm substance, like filberds, contains a great quantity of oil, and is very apt to grow rank, which is the reason why there are scarce two in ten that will germinate when sown. The natives make no manner of use of either the flowers or kernels.

The shrub must be, at least, of three years' growth, before the leaves, which it then bears in plenty, are fit to be plucked. In seven years' time, or thereabouts, it rises to a man's height; but as it then grows slowly, and bears but few leaves, the natives generally cut it down to the stem, after having first gathered what few leaves it produces. The next year, out of the remaining stem proceed many young twigs and branches, which bear such abundance of leaves, as sufficiently compensate for the loss of the former shrub. Some defer the operation of cutting down the stem till the shrub is of ten years' growth.

The leaves must not be torn off by handfuls, but plucked carefully, one by one, and are not to be gathered all at once, but at different times. Those who pluck their shrubs thrice a year, begin their first gathering about the end of February. The shrub then bears but a few leaves, which are very tender and young, and not yet fully opened, as being scarcely above two or three days' growth. These small and tender leaves are reckoned much better than the rest, and, because of their scarcity and price, are disposed of only to princes and rich people; for which reason

reason they are called Imperial-tea, and by some the flower of tea. The second gathering, and the first of those who gather but twice a year, is made about the latter end of March, or beginning of April; some of the leaves are then already come to perfection, others are but half grown; both, however, are plucked off promiscuously; though care is afterwards taken, previously to the usual preparation, to arrange them into classes, according to their size and goodness. The third and last gathering, which is also the most plentiful, is made in the end of May, when the leaves have attained their full growth, both in number and size. The leaves of this gathering are arranged in like manner as the former, according to their size and goodness, into different classes, the lowest of which contains the coarsest leaves of all, being full two months grown, and that sort which is commonly drank by the vulgar.

The preparation of the leaves consists in drying, or roasting them when fresh gathered, over the fire, in an iron pan, and rolling them, when hot, with the palm of the hand on a mat, till they become curled. The particulars of this preparation, as related by the ingenious author, from whom this description is extracted, are much too tedious for our purpose. The reader is therefore referred to the work itself. *Vide Kämpfer's History of Japan*, vol. 2, appendix 1.

The tea after having undergone a sufficient roasting and curling, must, when cold, be put up, and carefully kept from the air. In this, indeed, the whole art of preserving it chiefly consists; because the air, in these hot climates, dissipates its extremely subtle and volatile parts much sooner than it would in our colder European countries. The Chinese put it up in boxes of coarse tin, which, if they be very large, are inclosed in wooden cases of fir, all the clefts being first carefully stopped both within and without. After this manner also it is sent abroad into foreign countries. The Japanese keep their stock of the common tea in large earthen pots, with a narrow mouth. The better sort of tea, that which the emperor himself, and the great men make use of, is kept in porcelain pots or vessels, which is supposed to improve its virtues. The coarse tea of the third gathering, is not so easily injured by the air as the other sorts; for though its virtues are comparatively fewer, and less sensible, yet are they more constant and fixed. The country people keep it, as well as the other sorts which they use, in straw baskets, made like barrels, which they put under the roofs of their houses, near the hole which lets out the smoke; being of opinion, that nothing is better than smoke to preserve the virtues of the leaves, and even improve them. Some put it up with common mug-wort flowers, or the young leaves of a plant called *sasanqua*, which they believe renders it much more agree-

able. Other odoriferous and aromatic substances are found, upon trial, to produce no such beneficial effect.

The tea, as it is taken for drink, is prepared in two different ways. The first, used by the Chinese, and now all over Europe, is nothing but a simple infusion of the leaves in hot water. The other way, which is peculiar to the Japanese, is by grinding. In this preparation, the leaves are, by means of a hand-mill, made of a black greenish stone, called serpentine stone, reduced into a fine delicate powder, which being mixed with hot water, into a thin pulp, is afterwards sipped. This tea is called thick-tea, to distinguish it from the simple infusion, and is drank every day by all the rich people and great men in Japan.

The narcotic quality of the fresh unprepared leaves of tea, mentioned above, is destroyed, in a great measure, by a repeated and gradual roasting. This operation renders it exhilarating, refreshing, and cleansing. Kempfer observes, that tea is particularly serviceable in washing away that tartarous matter which is the efficient cause of calculous concretions, nephritic and gouty distempers; and affirms that among the great tea-drinkers of Japan he never met with any who were troubled with the gout or stone.

The leaves of tea, say writers on the *Materia Medica*, are much more used for pleasure than as medicine; the bohea, however, is esteemed softening, nourishing, and proper in all inward decays; the green is diuretic, carries an agreeable roughness with it into the stomach, which greatly astringes the fibres, and gives them such a tensility as is necessary for a good digestion. Improper, or excessive use, may no doubt, render this, or any thing else, prejudicial; but, in general, there are very few herbs employed, either in food or medicine, which, used with moderation, are better, pleasanter, or safer than tea.

After the most diligent enquiries that I have been able to make, I do not find, that the tea-plant grows naturally beyond the thirty fifth degree of north latitude on the one hand, and the forty-fifth degree on the other.

C I N N A M O N.

THE CINNAMON-TREE, the *laurus cinnamomum* of Linnæus, is a native of the island of Ceylon, in the East Indies. The leaves have three beautiful nerves, which run through the disk or surface, and disappear towards the top. The tree has three barks or rinds: the first and second are only used; the third, and innermost, which incloses the body of the tree, is never touched; not, as some have pretended, because it is of no value, but because

cause an incision in it kills the tree. After three years' time, the two extreme barks are renewed, and fit to be pulled off. When the Dutch, say some authors, who ingross the whole trade of this and the other spiceries, are apprehensive of abating the value of cinnamon, by sending home too great abundance, and thereby glutting the European markets, they lay it on an heap, and burn as much of it as they imagine useless for their service; which spicy mountain sends out its fragrant exhalations for many leagues into the sea; so that of these coasts, it may be truly affirmed, in the beautiful language of Milton, that

“Pleas'd with the grateful smell, old Ocean smiles.”

The Dutch, not remarkable for honesty in any of their dealings, are particularly fraudulent in conducting the spice trade: for they frequently extract a quantity of oil, essence, or spirits, from the cinnamon or cloves; and then confidently expose them for choice untainted commodities: hence we often meet with several spiceries, cinnamon in particular, that are very dry and insipid, almost devoid of smell or taste, and pillaged of their oil and essential substance. The fruit of the cinnamon-tree yields, by coction and expression, an oily substance, of which candles are made for people of the first rank; and from the neck of the root, is drawn a fine kind of camphor, of a spicy aromatic smell, very rarely to be met with in Europe.

C L O V E S.

THE common CLOVE, a native of the Molucca islands, is the unripe fruit of the *carophyllus aromaticus* of Tournefort and Linnæus. The ripe fruit, the mother cloves, or antophilli of the shops, is seldom seen. It is a secret among some, who deal largely in cloves, to keep them in a cellar or other damp place, where they will swell and increase considerably in weight, and look much better, though they are, in effect, much worse, than before such management. The fable of the other trees bending to the royal clove, mentioned by Pomet and Lemery, is to be taken as a figurative expression. The inhabitants of the island of Massia in the East-Indies, where the royal clove grows, string the fruit and make beads of it, which they wear about their necks, on account of the fragrancy of the smell.

Cloves, before they have attained maturity, are of a delightful colour. Some authors relate, that they are originally possessed of such an attractive spongy quality, as frequently to drain, with facility, any liquid that stands near them; so that, unless the master of the ship, which conveys them from the islands, is very careful to keep them at a convenient distance from his liquors,

liquors, a quantity of them will, in two days' time, exhaust and dry up a hoghead of wine or water.

P I M E N T O.

PIMENTO, ALL-SPICE, or JAMAICA-PEPPER, is the dried unripe fruit of the *piper odoratum Jamaicense* of Ray, the *myrtus pimento* of Linnæus; the *bay-berry-tree* of some authors. It is a round fruit, with a duskyish, hard, rough, umbilicated rind, containing within it two black kernels, of an aromatic smell and taste, approaching to that of cloves, yet partaking, in some degree, of the odour and taste of all the other spices, whence it has obtained the name of *all-spice*. The tree which produces it rises to the height of thirty or forty feet; and in a rich soil will grow even to the height of a hundred feet. The leaves are like those of the bay, but of a much stronger aromatic smell; the flowers stand in bunches, and are of a greenish colour; these are succeeded by the fruit, which the Negroes gather before it is ripe, and dry in the sun; in drying, it becomes wrinkled and brown, though formerly smooth and green. The tree grows naturally in hilly places, in the north part of Jamaica.

At Christmas, they usually adorn their churches, in the West-Indies, with small boughs of pimento; as the churches in England are decked with holly and ivy, at that sacred season.

B A N A N A.

THE fruit of the BANANA-TREE is four or five inches long, of the size and shape of a middling cucumber, and of a highly grateful flavour; the leaves are two yards long, and a foot broad in the middle; they join to the top of the body of the tree, and frequently contain in their cavities a great quantity of water, which runs out, upon a small incision being made into the tree, at the junction of the leaves. Bananas grow in great bunches, that weigh a dozen pounds and upwards. The body of the tree is so porous, as not to merit the name of wood: the tree is only perennial by its roots, and dies down to the ground every autumn.

When the natives of the West-Indies, says Labat, undertake a voyage, they make provision of a paste of banana; which, in case of need, serves them for nourishment and drink; for this purpose, they take ripe bananas, and having squeezed them through a fine sieve, form the solid fruit into small loaves, which are dried in the sun, or in hot ashes, after being previously wrapped up in the leaves of Indian flowering-reed. When they would make use of this paste, they dissolve it in water, which
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is very easily done, and the liquor, thereby rendered thick, has an agreeable acid taste imparted to it, which makes it both refreshing and nourishing.

The banana is greatly esteemed, and even venerated, by the natives of Madeira, who term it the forbidden fruit, and reckon it a crime almost inexpiable to cut it with a knife; because, after dissection, it exhibits, as they pretend, a similitude of our Saviour's crucifixion; and to cut the fruit open with a knife, is, in their apprehension, to wound his sacred image.

Some authors have imagined, that the banana-tree was that of the leaves of which our first parents made themselves aprons in Paradise. The sacred text, indeed, calls the leaves employed for that purpose, fig-leaves; and Milton, in a most beautiful, but erroneous description, affirms the bearded, or Bengal fig, to have been the tree alluded to. But, besides that the fruit of the banana is often, by the most ancient authors, called a fig, its leaves, by reason of their great size and solidity, were much more proper for a veil, or covering, than those of the Bengal fig, which are seldom above six or eight inches long, and three broad. On the other hand, the banana-leaves being three, four, and five feet long, and proportionably broad, could not fail to be pitched upon, in preference to all others; especially as they might be easily joined, or sewed together, with the numerous thread-like filaments, that may, with the utmost facility, be peeled from the body of this tree.

Y A M S.

YAMS, the root of the *dioscorea bulbifera* of Linnæus, are the principal food of the negroes in the West-Indies. The skin is pretty thick, rough, unequal, covered with many stringy fibres or filaments, and of a violet colour, approaching to black. The inside is white, and of the consistence of red beet; it resembles potatoes in its mealiness, but is of closer texture. When raw, these roots are viscous or clammy; when boiled, or roasted, they afford very nourishing food, and are often preferred to bread, by the inhabitants of the West-Indies, on account of their lightness and facility of digestion. The stem of the plant is square: when placed by itself, it trails upon the ground, and strikes root at proper distances; but when planted in the neighbourhood of bushes or trees, it avails itself of their support, climbs, and in a short time, covers every place to which it can penetrate. The leaves are opposite and shaped, like a heart; they are of a dark-green, pretty thick, and succulent. The flowers, which are small and bell-shaped, grow in spikes from the wings of the leaves, and are succeeded by dry capsular fruits, each containing several small

small, flat, black seeds. The plant, which is a native of Africa and the East-Indies, is propagated by the eyes of the root, in the same manner as potatoes and Jerusalem artichokes. When first dug out of the ground, the roots are placed in the sun to dry; after which, they are either put into sand, dry garrets, or casks, where, if kept from moisture, they may be preserved whole years, without being spoiled, or diminished in their goodness. Two or three pounds is the common weight of this root; some yams, however, weigh twenty pounds and upwards.

CASHEW-NUT.

THE CASHEW-NUT, or ACAJOU, is a native of both the Indies. It is a long, wide-spreading tree, and seldom exceeds twenty feet in height; the branches are crooked, straggling, and covered with oval leaves, resembling those of the ivy, or English dwarf-apple. The flowers are small, white, and cut into five segments or divisions. These are succeeded by the fruit, which is generally of a yellow colour, as large as an orange, of a conical form, with the lesser end towards the stalk on which it grows. At the greatest end, or outside top of this fruit, sometimes called the cherry, grows the stone, commonly styled the nut, quite bare, in the exact shape of a sheep or hare's kidney, about an inch long, containing within it a large white kernel, of a fine taste, which is roasted and eaten. The inside of the fruit or cherry is very stringy, and full of rough, astringent, but pleasant juice, which in America is frequently used, like that of lemons with us, in making punch.

The outer shell of the nut is of an ash-colour, and very smooth. Under this outer rind is another, which covers the kernel; between them is a thick black inflammable oil, which is very caustic.

When the West-India young ladies fancy themselves too much tanned by the scorching rays of the sun, they gently scrape off the thin outside skin of the stone, and then rub their faces all over with the stone. These immediately swell, and grow black; and the skin being thus poisoned, will, in the space of five or six days, come entirely off the face, in large flakes, so that they cannot appear in public under a full fortnight; by which time the new skin looks as fair as that of a young child.

The negroes in Brasil cure themselves effectually of disorders in the stomach, by eating of the yellow fruit of the acajou; the juice of which being acid, cuts the thick tough humour which obstructed the free circulation of the blood; and thus removes the complaint. This cure, however, is not voluntary; for their masters, the Portuguese, deny them any other sustenance; and
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letting them loose to the woods, where the cashew-nuts grow in great abundance, leave it in their option to perish by famine, or sustain themselves with what Nature has provided them.—It is this necessity which leads them to the fruit of the acajou, of which they are not fond; and after continuing the use of it for some days, they return to their masters perfectly recovered from their indisposition, and endued with strength to perform their customary labour.

The milky juice of the cashew-tree will stain linen of a deep black, which cannot be washed out again.

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Vegetables producing Poisonous.

MANCHINEEL.

THE fruit of the MANCHINEEL-TREE is one of the most powerful caustics, and, taken internally, never fails to prove mortal, if large quantities of oil be not immediately swallowed, to excite vomiting, and sheath the viscera, before the caustic juice has operated. The tree bears a great resemblance to the pear-tree; the bark is somewhat thicker, and filled with a white viscous corrosive milk; the wood under the alburnum is greyish, and beautifully marked with eyes of different tints or colours. The caustic and poisonous quality is not peculiar to the fruit, it is to be found also in the leaves, in the wood, in the milk of the bark, and even in its shade, by sleeping under it.

The tree, which is commonly large, grows in the West-Indies, on the banks of rivers, or on the sea-shore, being rarely found at a distance from the water. When it rains, one must be cautious of going under this tree for shelter, as the rain falling from its leaves on the hands, and other parts of the body, raises blisters on the flesh, as if boiling oil had fallen upon it, together with a very painful itching, which continues for a long time. If it falls into the eyes, it will endanger the eye-sight; or if by chance one should rub them with his hand, moistened with this water, a considerable swelling is occasioned, which from being red, becomes livid and full of pus.

The wood is no less dangerous to work, unless perfectly dry, and even its dust or sawings are poisonous. Before it is touched, the workmen amass dry wood around its feet, set fire to it, and keep at a distance for fear of any bad consequences from the smoke. When they think the fire has totally consumed its humidity, they apply the hatchet, taking care to have their faces and

arms covered with a towel or napkin, lest the dust flying out of it, or the milky humidity which may have remained unevaporated, should fly in their faces, mouths, eyes, or hands. The sawyers use the same precautions, as well as the turners, who work it into tables, cabinets, and all sorts of household furniture, which are greatly esteemed for the uncommon beauty of the wood.

The Indians use the milk of the manchineel-tree to poison their arrows; for this purpose they make a cleft in the bark, and insert the end of their arrows, which imbibes the liquor flowing out of the wound, that is as white as milk, but thicker and more gluey. The arrows so, envenomed, are suffered to dry; and where they make a wound, they poison at the same time.

Those who sleep under the manchineel-tree, find themselves, on awaking, prodigiously swelled, with a very violent megrim, and a dangerous fever. By force of citron-juice and cordials, the venom is often extirpated.

A species of euphorbia, termed *esula*, if applied to any part of the body, produces a violent inflammation, which is soon succeeded by a considerable swelling, that degenerates into a gangrene, and proves mortal.

IPECACUANHA, that well known medicine, is the root of another species of the same genus, the *euphorbia ipecacuanha* of Linnæus. *Sterculia* (*stercus*, dung) derives its name from the foetid smell of the wood, which is said to resemble that of human excrements; whence the name of dirt-wood, by which it is known in the hot countries, where it is native.

C A S S A D A.

THE root of CASSADA or MANIHOT, being divested of its poisonous juices, serves for bread to most of the inhabitants of the West-India islands, whether black, white, or red; that is, Negroes, Europeans, and Natives. The shrub, sometimes called MANIOC, rises seven or eight feet high, with a thin bark, that is grey, red, or violet, according to the different colours of the wood which it covers. The trunk and branches are filled with small prominences or knots, exhibiting the vestiges of the fallen leaves; for as the tree increases in height, the leaves relinquish the bottom of the branches, and are only to be found near the top. The wood is soft and brittle. The plant is better propagated by layers than from seed; at least, little of the root proper for eating is to be obtained by the latter method. The principal root produces suckers, in number from four to seven, and of different lengths and thickness, according to the age of the tree and goodness of the soil. The bark of the roots is like that of the trunk, grey, when the wood is grey; red, when red; white,

white, when white; but the inside, or heart, is always white, and of the consistence of turnips.

The roots of white manioc are ripe in eight months; those of the other kinds require fourteen or eighteen months to attain their full size and maturity. When ripe, they are plucked out of the earth by tearing up the whole tree, which never fails to be accompanied by the root; and, if in that operation, any of the off-sets should be separated from the main root, which is easily observed, they take them up with a hoe. It requires no great force to pluck up these shrubs; for, besides that the soil is of a soft nature, the roots do not penetrate very deeply into it.

When plucked up, the negroes destined for this work, grate or rasp the bark with a blunt knife, as is done to turnips, and then throw them into a tub full of water; they are then reduced to a powder or meal, resembling coarse sawings of wood; this is effected by rubbing the root very forcibly against a copper file or grater, about fifteen or eighteen inches long, and ten or twelve broad, that is fastened by small nails upon a plank of timber, three feet and a half long, and one broad. The negro who files, puts one end of the plank into a wooden trough or tub, and holds the other against his stomach; at his side is a basket, containing roots that are rasped, washed, and fit for being filed; one of these he takes in each hand, and passes it violently upon the file or grater till it is reduced to a rough powder.

All the roots being grated in this manner, they take the powder and put it into a press, with a view to squeeze out the juice, which is regarded as a very strong poison, not only for men, but for beasts also, who drink of it, or chance to eat of these roots before the juice is expressed. It is remarkable, that animals which die in consequence of having swallowed any quantity of this substance have their breasts prodigiously swelled, without any visible alteration on the nobler parts. Some have hence argued that the juice in question is not essentially a poison; but that possessing a superfluity of nourishment, it proves an over-match to the digestive faculties, and thus proves mortal.

Beside this superabundance of nourishment, says Father Labat, a part of its malignity consists in its coldness, which stops the circulation, benumbs the animal spirits, and at length causes death: hence the best antidote against this poison is heat and violent motion. The patient after swallowing large quantities of oil, to excite a nausea and vomiting, is made to run as quick as he can, and drink plentifully of the strongest spirits; in fine every method is used to excite violent heat, to rouse the spirits, and put the blood in motion.

Animals which have accustomed themselves insensibly to the juice of manioc, feel no inconvenience from the root of it, but

ther the contrary. So the Turks, by a gradual and constant use, have rendered opium a harmless and even exhilarating medicine.

The juice of the manioc loses its malignity when heated. The natives of the West-Indies, who use it in all their sauces, feel no sort of inconvenience from it, because they never use it till after it is boiled. Of the same juice they make starch, by drying it in the sun, where it becomes as white as snow, and is frequently made into cakes, which are as delicate as if made with the finest wheat-flour.

When the manioc is sufficiently pressed, they either make it into bread, called cassada, or into flour, for preserving. For the first-mentioned purpose, they have a plate of iron, two feet broad, and half an inch thick; this they place upon a tripod, or on stones, and kindle a fire below it. When sufficiently heated, so as not to admit of the touch, they lay on the whole surface about the thickness of three fingers of manioc, which has been previously pressed and sifted. The heap falls down in proportion as it roasts; and the parts join and incorporate. This compression and incorporation is aided by the person who roasts slightly passing a piece of wood over the plate. When the side of the cake next the plate, is sufficiently done, that is, adheres, and the colour, formerly very white, becomes very red, it is turned, and the other side allowed to roast till the same symptoms appear. When roasted it is laid in the sun for two or three hours, with a view to dissipate any poisonous humidity which may still lurk in the root, under this new form.

The inside of cassada is as white as snow, the sides of a pale gold colour; the substance, which is very nourishing, and of easy digestion, may be preserved seven or eight months, or more, provided it is kept dry, and sometimes exposed to the sun. When dipped in water or put into soup, cassada swells to a great height, which seems to prove its great abundance in substance.

The other mode of preparation, however, is most common, as being more convenient for preserving, distributing to the negroes, and transporting from place to place. The manioc, in this case, is put into a pan or stove, that is but slightly heated, where it is continually turned, like coffee-beans, with a small wooden instrument, contrived for that purpose. This motion prevents it from sticking to the pan; so that when dried and roasted, it has the appearance of thick red grains of salt. This mode of preparation is much more expeditious than the former. When dried, it is put in granaries, where it may be preserved whole years, if kept dry, or put into a stove every six months.

This substance may be eaten quite dry, as crumbled bread, or as
the

the Turks eat roasted rice. When moistened, it swells prodigiously.

This latter method of preparing manioc is never practised by the natives, who use only cassada, which they prepare only once every day, or oftener, as occasion requires; for they eat it quite hot, as being then more delicate and agreeable to the taste. Before their intercourse with the Europeans had procured them iron plates, they made their cassada upon large flat stones, whose thickness they adjusted to that purpose. In default of copper files or grates, they made use of a plank of wood, in which were fixed very small sharp bits of pebbles.

One species of manioc is said to be exempt from the poisonous quality possessed by the juice of the others; it is called camanioc, that is chief of manioc; in fact, its wood, leaves, and roots are larger and thicker than the others, and it is eaten without danger, or any precaution; but as it is longer in growing and ripening, and the roots yield much less meal, because lighter and more spongy; it is generally neglected.

The small bits of manioc which have escaped the grater, and the clods which have not passed the sieve, are not useless. They are dried in the stove, after the flour is roasted, and then pounded in a mortar, to a fine white powder, with which they make soup. It is likewise used for making a kind of thick coarse cassada, which is roasted till almost burnt; of this, fermented with melasses and West-Indian potatoes, they prepare a much esteemed drink, or beverage, called ouycou. This liquor, the favourite drink of the natives, is sometimes made extremely strong, especially on any great occasion, as a feast; with this they get intoxicated, and, remembering their old quarrels, massacre and murder each other. Such of the inhabitants and workmen as have not wine, drink ouycou. It is of a red colour, strong, nourishing, refreshing, and easily inebriates the inhabitants, who soon accustom themselves to it as easily as beer.

The leaves of manioc are used in both Indies, as those of spinnage are with us.

TOXICODENDRON.

THE exhalations of the POISON-TREE (TOXICODENDRON) which Linnæus has joined, somewhat improperly, to the fumachs, are said to produce small red spots on the skin, not unlike those eruptions vulgarly known by the name of St. Anthony's Fire. The slightest touch of the leaves produces very violent itchings, which are sometimes followed by an inflammation and swelling. If the juice of any species of the poison-tree is suffered to remain but for a few minutes on the skin, it occasions pustules, which are sometimes mistaken for the itch.

The wood of the poison-tree, when burnt, emits a very noxious fume, which is said to suffocate animals that are exposed to it.

The juice of some poison-trees, when exposed to the heat of the sun, becomes so resinous and clammy, that it proves a good bird-lime, and is used with great success for that purpose.

A cataplasin of the new extracted juice of a species of poison-tree, mentioned by Hughes, in his "Natural History of Barbadoes," applied to the feet, is said to kill the vermin, called by the West-Indians, chighers.

The Americans, it is said, pretend to distinguish the poison-ash (*rhus vernix*) by the touch, in the dark, from its extreme coldness,

DOGWOOD.

DOGWOOD-TREE, the *piscidia erythrina* of Linnæus, which grows plentifully in the West-Indies, is chiefly noted for the quality said to be possessed by its bark, of intoxicating fish, which, by that means, become an easy prey to those who employ this stratagem against them. When any number of gentlemen have an inclination to divert themselves with fishing, or more properly speaking, with fish-hunting, they send each of them a negro-slave to the woods, in order to fetch some of the bark of the dogwood-tree. This bark is next morning pounded very small with stones, put into whole sacks, carried into rocky parts of the sea, steeped till thoroughly soaked with salt-water, and then well squeezed by the negroes to express the juice; this juice immediately colours the sea with a reddish hue, and being of a poisonous nature, will, in an hour's time, make the fishes, such as groopers, rock-fish, old wives, welchmen, &c. so drunk, or intoxicated, as to swim on the surface of the water, quite heedless of the danger; the gentlemen then send in their negroes, who pursue, both swimming and diving, the poor inebriated fishes, till they catch them with their hands; their masters, mean-time, standing by, on high rocks, to see the pastime.

It is remarkable, that though this poison kills millions of the small fry, it has never been known to impart any bad quality to the fish which have been caught in consequence of the intoxication.

The wood of this tree, although pretty hard, is only fit for fuel; and even for this purpose, the negroes very seldom, if ever, employ it, on account of its singular quality, just mentioned. The bark is rough, brown, and thick; the tree sends forth a considerable number of branches, and is well clothed with leaves, which resemble those of the pea, are thick, cottony, and of a deep green. The bark used for the above-mentioned purpose, is chiefly that of the roots.

A R R O W-

A R R O W - R O O T.

INDIAN ARROW-ROOT is the only remedy yet known against wounds made by arrows poisoned with the milky juice of the manchineel-tree. The natives of the Caribbee Islands, where it naturally grows, call it *toulola*; it resembles Indian flowering-reed, except in its height, which seldom exceeds four feet; the flower is white, and is succeeded by a fruit with three sides like a prism, of a pale red, and very sleek, containing a small, wrinkled, or furrowed seed; the root is a long, white, jointed, watery, and mealy bulb, from which hang a great number of long dry fibres; the leaves are strong, almost as firm as parchment, of a light green, curl themselves as soon as gathered, and are attached to the trunk by a long furrowed stalk; they are round below, four times longer than broad, and end in a point, like the extremity of a spear, or halbert. The root is pounded, infused in water, and made into ptisan, which is drank by those who have been wounded with poisoned arrows: it has the virtue of dissipating the *virus*, and of preventing it from reaching the noble parts. The same root bruised, and made into a cataplasm, is applied externally to the wound, and with great efficacy, if quickly used; but if delayed, though for a very short time, the poison gains ground, corrupts the parts adjoining to the wound, and having communicated its virulence to the larger vessels, proves mortal. Of the root of this plant is likewise made an exceedingly fine starch, far surpassing that made with wheat.

C O T T O N.

THE silk COTTON-TREE is a native both of the East and West Indies, and takes its name from the fine silky down with which the seeds are wrapped within the capsule, and which, in different species, is of different colours, and in different degrees of estimation. The dark short down, or cotton, is seldom used, except by the poorer sort, for stuffing pillows or chairs; being generally esteemed unwholesome to lie upon. The beautiful purple down of the *bombax villosus* is spun, wrought into clothes, and worn, without being dyed, by the inhabitants of the Spanish West-Indies, where the tree naturally grows.

Large pirogues, or canoes, fit to carry a sail, are made both at Senegal, and in America, of the trunk of the silk cotton-tree, the wood of which is very light, and found unfit for any other purpose. In Columbus's first voyage, says Miller, it was reported a canoe was seen at the island of Cuba, made of the hollowed trunk of one of these trees, which was ninety-five palms long

long, of a proportionable width, and capable of containing a hundred and fifty men.

Bosman, in his Description of Guinea, says, he has seen of these trees so widely diffused, that 20,000 men, closely armed, might easily stand under the branches.

Cotton-wool is the produce of the small, or shrubby cotton-tree. This plant grows in form of a bush, and sends forth branches that stretch wide, and are garnished with leaves somewhat less than those of the sycamore, but almost of the same shape. It bears a great many fine yellow large flowers, composed of five petals, each of which is tinged at the bottom with a purple colour. The seed-bud, which is of the same colour, is placed in the middle of the flower. It is of an oval or conic shape, and grows in time to the size of a pigeon's-egg. When ripe, it becomes black, and splits into three or four partitions at top, discovering the cotton, or down, which infolds the seeds, and appears white as snow, in as many flakes as there are cells, or internal divisions in the capsule. In these flakes, which swell with the heat to a considerable bigness, are interspersed several black seeds, as large as lupines, of a sweet taste, white within, oily, and adhering together.

The cotton, of which, in the East-Indies, they make their finest calico, is too well known to require a farther description. Suffice it to observe, with Mr. Hughes, in his Natural History of Barbadoes, that indulgent Providence has sufficiently supplied the want of wool, denied to the sheep in the warmer climates, by causing a vegetable, in such countries, to bear the finest wool in the world.

The certainty of gathering a good crop of this kind, is very precarious; since it may be almost literally said of this shrub, that in the morning it is green, and flourishes, and almost in the same evening, withers, and decays. For when the worms begin to prey upon a whole field of cotton-trees, though they are at first scarcely perceptible to the naked eye, yet, in three days, they will grow to such a size, and prove so destructive, as to reduce the most verdant field, thickly and beautifully clothed with leaves and flowers, into almost as desolate and naked a condition as trees are in the month of December, in England. When these worms, which are of the caterpillar kind, have attained their full growth, they spin and inwrap themselves as in a bag, or web, like silk-worms, in the few remaining leaves, or any other covering: and after a few days' rest in this their Aurelia state, turn into dark-coloured moths, and fly away.

Cotton-flowers, if carefully wrapped up in leaves of the same tree, and baked or roasted over a fire of burning coals, yield, says Pomet, a reddish viscous oil, that quickly cures old standing ulcers,

cers. Of the black seed, an oil may be made, which beautifies the face, removes spots and freckles, and possesses the same virtues with the oil of cokar-kernels. The cotton, or down itself, is said to do wonders in the gout, by being burnt upon the part; but its efficacy can be no other than that of fire, or quicklime; whatever good attends this practice being wholly owing to the burning.

CHINA-ROSE.

THE flowers of the CHINA-ROSE, *hibiscus sinensis*, alter remarkably in their colour. At their first expansion, they are white; they then change to a deep red, or rose colour, which, as they decay, turns to a purple. In the West-Indies, where it goes by the name of Martinico rose, all these alterations happen in the course of one day; which, in these hot countries, is the longest duration of the flowers in question; but in England, where they continue near a week in perfection, the changes are not so sudden.

INDIGO.

FROM the leaves and small branches of the *indigofera tinctoria* of Linnæus, is prepared that excellent dye, known by the name of indigo. The leaves, when ready for this purpose, are cut down, and thrown into large vats of water, where they are suffered to steep till a violent fermentation ensues, and the water acquiring heat, boils up on every side of the infused leaves, and insensibly becomes of a violet colour. When these effects, which generally happen after sixteen or eighteen hours' infusion, are observed, the water is conveyed, by means of cocks at the bottom of the vat, into another vessel, of the nature of a churn, where it is worked, by a negro, with great violence, till the water abounds with a lather, and the salts, and other parts of the substance of the plant are sufficiently united. It is then allowed to settle, and the water, which becomes as clear as at first, is drawn off by means of cocks, leaving at the bottom of the vessel, a sediment or *fecula*, like the lees of wine, which, when dried, is the valuable dye known by the name of indigo.

The negroes on the coast of Guinea, gather the leaves of the indigo-plant at any time of the year, and having pounded them in a mortar, make the paste up into loaves, which they preserve dry. When they want to make use of them in dying, they dissolve them in a kind of ley, made of the ashes of an unctuous plant which grows in their fields, the *portulaca marina latifolia* of Plumier, by the negroes called *rheme*. This ley imbibes a tincture of the indigo, into which they dip their linen,

cold, as often as they think necessary, according to the deepness of the colour required.

LARCH-TREE.

FROM the LARCH-TREE is extracted what we erroneously call Venice-turpentine. This substance, or natural balsam, flows, at first, without incision; when it has done dropping, the poor people who wait in the fir-woods, make incisions at about two or three feet from the ground, into the trunk of the trees, into which they fix narrow troughs, about twenty inches long. The end of these troughs is hollowed, like a ladle; and in the middle is a small hole bored, for the turpentine to run into a receiver, which is placed below it. As the gummy substance runs from the trees, it passes along the sloping gutter, or trough, to the ladle, and from thence runs through the hole into the receiver. The people who gather it, visit the trees morning and evening, from the end of May to the beginning of September, to collect the turpentine out of the receivers. When it flows out of the tree, Venice-turpentine is clear, like water, and of a yellowish white; but, as it grows older, it thickens, and becomes of a citron colour. It is procured in greatest abundance in the neighbourhood of Lyons, and in the Valley of St. Martin, near Lucerne, in Switzerland.

From the wild pine, or pineaster is extracted the common turpentine, which is chiefly used by the farriers, and from which is distilled the oil of that name. The finer and more valuable part of the distillation comes first, and is called the spirit, what is left at the bottom of the still, is the common resin.

The pitch-tree, a species of fir, produces the substance from which it derives its name.

The large branches of the larch-tree, besides turpentine, produce several small grains, like sugar, which possessing the purgative quality of manna, have likewise obtained its name.

Taken internally, these plants are warming, aperient, sudorific, diuretic, stomachic, and antiseptic. An air impregnated with their balsamic exhalations, is reckoned very salutary to consumptive habits.

Juniper-berries, and the gum of the larch, give urine a fragrant smell, like that of violets. The cones or female heads of the cypress, improperly called cypress-nuts, are highly astringent. Juniper-wood is sudorific in decoction, and fragrant when burnt: for which purpose it is frequently used in houses, to prevent pestilential disorders, and other infections.

From the seeds, or nuts of the cultivated pine, is drawn, by expression, an oil, which is equal, in point of excellence, to that obtained

tained from hazel-nuts. These same nuts, or kernels, are frequently served up in deserts, during the winter season, in Italy; formerly they were used in medicine in this country; but of late years, the pistacia nuts have been generally substituted in their place. Of the soft white substance, commonly called *alburnum*, which in trees lies betwixt the wood and the inner bark, the Swedes prepare a dish that is esteemed a great delicacy, and much used in spring. In times of scarcity, a sort of bread is made of the bark.

C Y P R E S S.

THE timber of the horizontal cypress, a native of the Levant, is said to resist worms, moths, and all putrefaction; and to last many centuries. The coffins in which the Athenians used to bury their heroes, were made, says Thucydides, of this wood, as were likewise the chests containing the Egyptian mummies. The doors of St Peter's church, at Rome, were originally of the same material. These, after lasting eleven hundred years, at the end of which time, they discovered not the smallest tendency to corruption, were removed, by the order of Pope Eugenius IV, and gates of brass substituted in their place.

The same tree is by many eminent authors recommended as improving and meliorating the air by its balsamic and aromatic exhalations; upon which account, many of the ancient physicians of the eastern countries used to send their patients who were troubled with weak lungs, to the island of Candia, where these trees grew in great abundance, and where, from the salubrious air alone, very few failed of obtaining a perfect cure.

In the same island, says Miller, the trees in question were so lucrative a commodity, that the plantations were called *Dos Filiae*, the selling of one of them being reckoned a daughter's portion.

Cypress, says Mr. Pocock, is the only tree that grows towards the top of Mount Lebanon, and being nipped by the cold, does not grow spirally, but like a small oak.

The leaves of common favin, a species of juniper, are much used by farriers for destroying worms in horses.

C E D A R.

THE red wood of Bermudas Cedar, the *Juniperus Bermudiana* of Linnæus, commonly known in England by the name of cedar-wood, is used for making pencils, as likewise for wainscoting rooms, and making stair-cases. It is remarkable that the worms are never found to eat the bottoms of vessels built with this wood, as they do those built with oak; so that for the West Indian seas, cedar ships are preferable to all others; but they are not equally fit

to be employed as ships of war; the wood being so brittle as to split to pieces when struck by a cannon-ball.

The peasants in Switzerland, make torches for burning, of the wood of a mountain pine, which grows naturally in that country, and is hence denominated the *torch-pine*

Cedar of Lebanon is the *Pinus Cedrus* of Linnæus, and the *Larix Cedrus* of Tournefort. The truth is, that this curious tree bears the leaves of the larch; but as the fir, pine, larch, and cedar, are all arranged by Linnæus under the genus *Pinus*, he could not, without erecting a new genus, make the cedar in any other respect, connected with the larch, than as they were both species of the same genus.

The wood of this celebrated tree, which grows naturally on Mount Libanus, in Syria, and no where else, is accounted proof against all putrefaction of animal bodies; and said to yield an oil, excellent for preserving books and writings. It is thought by Lord Bacon, to continue sound a thousand years. The statue of Diana, in the famous temple at Ephesus, is affirmed to have been of this valuable material, as was most of the timber work of that wonderful structure. In the temple of Apollo, at Utica, there was found cedar-wood near two thousand years old.

The largest cedar, mentioned by Dr. Pocock, measured twenty-four feet in circumference.

B A O B A B.

THE age of this tree is no less remarkable, than its enormous size. M. Adanson relates, that in a botanical excursion to the Magdalen Islands, in the neighbourhood of Goree, he discovered some calabash-trees, from five to six feet diameter, on the bark of which were engraved, or cut to a considerable depth, a number of European names. Two of these names, which he was at the trouble to repair, were dated one in the fourteenth, the other in the fifteenth century. The Letters were about six inches long, but in breadth they occupied a very small part only of the circumference of the trunk: from whence he concluded, they had not been cut when these trees were young. These inscriptions, however, he thinks sufficient to determine pretty nearly the age which these calabash-trees may attain; for even supposing that those in question were cut in their early years, and that trees grew to the diameter of six feet in two centuries as the engraved letters evince, how many centuries must be requisite to give them a diameter of twenty-five feet, which perhaps is not the last term of their growth!

The inscribed trees, mentioned by this ingenious Frenchman, had been seen in 1555, almost two centuries before, by Thevet, who

who mentioned them in the relation of his voyage to Terra Antartica, or Australis. Adanson saw them in 1749.

M A N G R O V E.

MANGROVES, the *mangles* of Plumier, are often forty or fifty feet high; they grow only in water, and on the banks of rivers, where the tide flows up twice a day. They preserve the verdure of their leaves throughout the year. From the lowest branches issue long roots, which hang down to the water, and penetrate into the earth. In this position they resemble so many arcades, from five to ten feet high, which serve to support the body of the tree, and even to advance it daily into the bed of the water. These arcades are so closely intertwisted one within another, that they form a kind of natural and transparent terrace, raised with such solidity over the water, that one might walk upon them, were it not that the branches are too much encumbered with leaves. The most natural way of propagating these trees, is to suffer the several slender small filaments which issue from the main branches, to take root in the earth. The common method, however, is that of laying the small lower branches in baskets of mould or earth, till they have taken root.

The description just given, pertains chiefly to a particular species of mangrove, termed by the West-Indians, *black-mangles*, on account of the brown dusky colour of the wood. The bark is very brown, smooth, pliant when green, and generally used in the West-India islands for tanning of leather. Below this bark lies a cuticle, or skin, which is lighter, thinner, and more tender. The wood is nearly of the same colour as the bark; hard, pliant and very heavy. It is frequently used for fuel, for which purpose it is said to be very proper: the fires which are made of this wood, being both clearer, more ardent and durable than those made of any other material whatever.—The wood is compact, almost incorruptible, never splinters, is easily worked, and, were it not for its enormous weight, would be commodiously employed in almost all kinds of work, as it possesses every property of good timber.—To the roots and branches of mangroves that are immersed in the water, oysters frequently attach themselves; so that wherever this curious plant is found growing on the sea-shore, oyster-fishing is very easy; as in such cases, these shell-fish may be literally said to be gathered upon trees.

The RED MANGLE, or MANGROVE, grows on the sea-shore, and at the mouth of large rivers, but does not advance, like the former, into the water, it generally rises to the height of twenty or thirty feet, with crooked knotty branches, which proceed from all parts of the trunk. The bark is slender, of a brown colour,

and

and when young, is smooth, and adheres very closely to the wood; but when old appears quite crackled, and is easily detached from it. Under this bark is a skin as thick as parchment, red, and adheres closely to the wood, from which it cannot be detached till the tree is felled and dry. The wood is hard, compact, heavy, of a deep red, with a very fine grain. The pith or heart of the wood being cut into small pieces, and boiled in water, imparts a very beautiful red to the liquid, which communicates the same colour to wool and linen. The great weight and hardness of the wood prevents it from being generally used. From the fruit of this tree, which, when ripe, is of a violet colour, and resembles some grapes in taste, is prepared an agreeable liquor, much esteemed by the inhabitants of the Caribbee islands,

WHITE MANGLE, so termed from the colour of its wood, grows, like the two former, upon the banks of rivers, but is seldom found near the sea. The bark is grey; the wood, as we have said, white, and when green, supple; but dries as soon as cut down, and becomes very light and brittle. This species is generally called rope-mangrove, from the use to which the bark is applied by the inhabitants of the West-Indies. This bark, which by reason of the great abundance of sap, is easily detached, when green, from the wood, is beaten or bruised betwixt two stones, until the hard and woody part is totally separated from that which is soft and tender. This last, which is the true cortical substance, is twisted into ropes of all sizes, which are exceedingly strong, and not apt to rot in the water.

A V O C A T O.

THE AVOCATO or AVIGATO pear-tree, a native of the West-India islands, so called from its fruit, which in form and thickness resembles a pear, is the *Laurus persea* of Linnæus. The pulpy or fleshy part of the fruit is of a pale green, with little or no consistence when ripe, and melts in the mouth like marrow, which it greatly resembles in taste.—The skin is smooth and thin, but of a strong tough substance and a beautiful green colour, which does not become yellow till the fruit is perfectly ripe. Yet the fruit, by reason of its softness, may be eaten out of the surrounding skin with a tea-spoon, like jelly and marmalade. It is frequently served up in the West-Indies, on a plate, with sugar, rose-water, and orange-flowers; most commonly, however, it is mixed with sugar, and the juice of limes, which render it extremely palatable.

The unripe fruit too is frequently plucked and eaten in thin slices, with pepper and salt. In this stage, the taste of the avocado greatly resembles that of artichokes. Every preparation of this fruit is esteemed highly nourishing; as it warms, exhilarates, and fortifies

fortifies the stomach.—It is particularly recommended in dysenteries.

In the middle of the pulpy part of the fruit lies the nut or seed, which is very large, almost round, of a pale russet colour, a little wrinkled, contains no kernel within it, and whose degree of hardness does not exceed that of a chestnut divested of its skin. This nut, about an hour after it is separated from the fruit, splits of itself into two or three pieces. If committed to the ground in this state, no vegetation ensues, because the embryo of the seed is broken; so that such as would propagate these plants from seed, must sow the nuts the moment they are taken out of the pulp; in which case they will begin to germinate in eight or ten days after.

R E E D S.

OF the stems of the bamboo cane, a species of reed, the natives of India, where the plant naturally grows, make most of their common utensils.

The eastern reed grows plentifully in Syria and Palestine. This is the reed of which the Turks make their writing-pens.

The stalks of *arundo donax* are used for fishing-rods.

There are two sorts of reed, says Hasselquist, growing near the Nile; one of them has scarcely any branches, but is furnished with numerous leaves, which are narrow, smooth, channelled, on the upper surface; and the plant is about eleven feet high. The Egyptians make ropes of the leaves. They lay them in water, like hemp, and then make them into good strong cables. These, with the bark of the date-tree, are almost the only cable used in the Nile. The other sort is of as great consequence. It is a small reed, about two or three feet high, full branched, with short, sharp, lancet-shaped leaves. The roots, which are as thick as the stem, creep and mat themselves together to a considerable distance. This plant seems useless in common life; but to it, continues our learned author, is the very soil of Egypt owing: for the matted roots have stopped the earth which floated in the waters, and thus formed, out of the sea, a country that is habitable.

.....

Mr. Ray, in his "Wisdom of God in the Creation," justly observes, that it is no small instance of the great Creator's goodness, that wheat, and the most common corn used for food, should be the growth of most parts of Europe and Asia. It is likewise no less worthy of observation, that where the soil under the torrid

zon^e

zone is too hot to produce wheat, the same divine wisdom hath appointed other kinds of corn to grow and ripen there, in great plenty. Thus, in Africa and the West-Indies, this want is supplied by Indian and Guinea-corn: and, in some places, where the excessive heat of the climate renders labour and the cultivation of corn painful, there bountiful Providence, with an unsparing hand, ordains food without labour, by causing banana and plantain-trees to grow in great plenty, whose fruit is, by many persons, preferred to any kind of bread whatever.

O R C H I S.

THE flowers of the different species of ORCHIS and OPHRYS are remarkably various and singular in their shape; resembling sometimes a naked man, sometimes a gnat, a butterfly, a drone, a pigeon, an ape, a parrot, a lizard, or a fly. These resemblances have given names to the species in question. The beard or *nectarium* of the bee-flower, is a large fat leaf, beautifully representing a drone or bee, of a sooty colour, and which when turned to the light, seems variegated with three bright yellow circular lines, with rust-coloured spaces between them. The *nectarium* of humble-bee satyrion, the *testiculus sphagodes hirsuto flore* of Ray, is remarkable for two upright lines, of a livid colour, and a transverse one of the same colour, representing a capital H. The flowers of many of the orchis tribe are beautifully spotted.

W A T E R S O L D I E R.

A Species of WATER-SOLDIER, or marsh-aloe, is the surprising plant which is said to move in the waters of the Nile, seeking for nutrition in the same manner as animals. The fact is, that the plant produces tufts of leaves, at a very great distance from each other, and supported by a stem, which after floating on the water, loses itself insensibly in the earth.



Nº 1.



Convolute

Nº 2.



Involute

Nº 3.



Revolute

Nº 4.



Doubled

Nº 5.



Enclosed

Nº 6.



Tile-like

Nº 7.



Obvolute

Nº 8.



Plaited

Nº 9.



*Convoluta
several Convolutes*

Nº 10.



*Involute
opposite*

Nº 11.



*Involute
alternate*

Nº 12.



*Revolute
opposite.*

Nº 13.



*Enclosed
lozenge shaped.*

Nº 14.



*Enclosed
Triangular.*

FOLIATION.

P L A T E S

ILLUSTRATIVE OF THE PRINCIPLES OF

B O T A N Y.

.....

P L A T E I.

THIS plate illustrates the different kinds of ROOTS, p. 27.

P L A T E II.

THIS plate illustrates the different kinds of TRUNKS, p. 28.

P L A T E S III, & IV.

THESE plates exemplify the general forms of SIMPLE LEAVES, as distinguished and named, page 30, &c.

P L A T E S V, & VI.

THESE plates exemplify the general forms of COMPOUND LEAVES, as distinguished and named, page 35.

N.B. The distinctions of DETERMINATE LEAVES should be very strongly committed to memory by the student; as the pleasure of this study often arises from circumstances and accidents which do not admit of reference to a book, for information.

The terms, &c. on these plates are entirely written in English, for the ease of the learner; this is not meant to disparage an acquaintance with the Latin terms, but to show the propriety of the names, and distinctions adopted.

P L A T E VII.

This plate shows the various contrivances of nature, to effect the purpose of supporting plants, or their parts and branches. This plate illustrates the principles, page 38.

P L A T E VIII.

Besides the external figure of leaves, there are many varieties in the manner of their being combined together, in those plants which consist principally of leaves; an idea of which may readily be formed from the figures and names inserted on this plate.

Part IV, No. 26.

N

PLATE

PLATE IX.

.....

ILLUSTRATIONS OF THE CALYX.

No.

1. A flower of the *Oleander*, showing the flower-cup (*perianthium*) inclosing the fructification.
2. The flower-cup, shown separate, for the purpose of greater distinctness; it consists of only one petal, but divided into five parts. *Monopetalous, quinquefid.*
3. The flower of the *Crassula*: showing its general appearance.
4. The flower-cup separated: showing its five petals distinctly.
5. Part of the *Canna*, or *Indian flowering-reed*: showing a flower-cup, which incloses the flower, but not the germen below it.
6. Part of the flower of the *black-berried Heath*, or *Crowberries*: showing a *perianthium* inclosing the fruit.
7. The *perianthium*, or flower-cup, separate.
8. A catkin (*amentum*) proceeding from a common receptacle: as in the *Walnut*.
9. A sheath, or *spatula*; the garden *Crocus*.
10. A glume, the flower of grasses in general; having a long beard, *arista*; the common *Oat*.
11. The calyx, *a, a*, opened in order to show its inclosure.
12. *Calyptra*, a veil, in mosses.
13. The parts separated. These are greatly magnified for the sake of distinctness; this instance is the common *Bryum*.

N.B. For INVOLUCRUM, see Plate XII, No. 5.

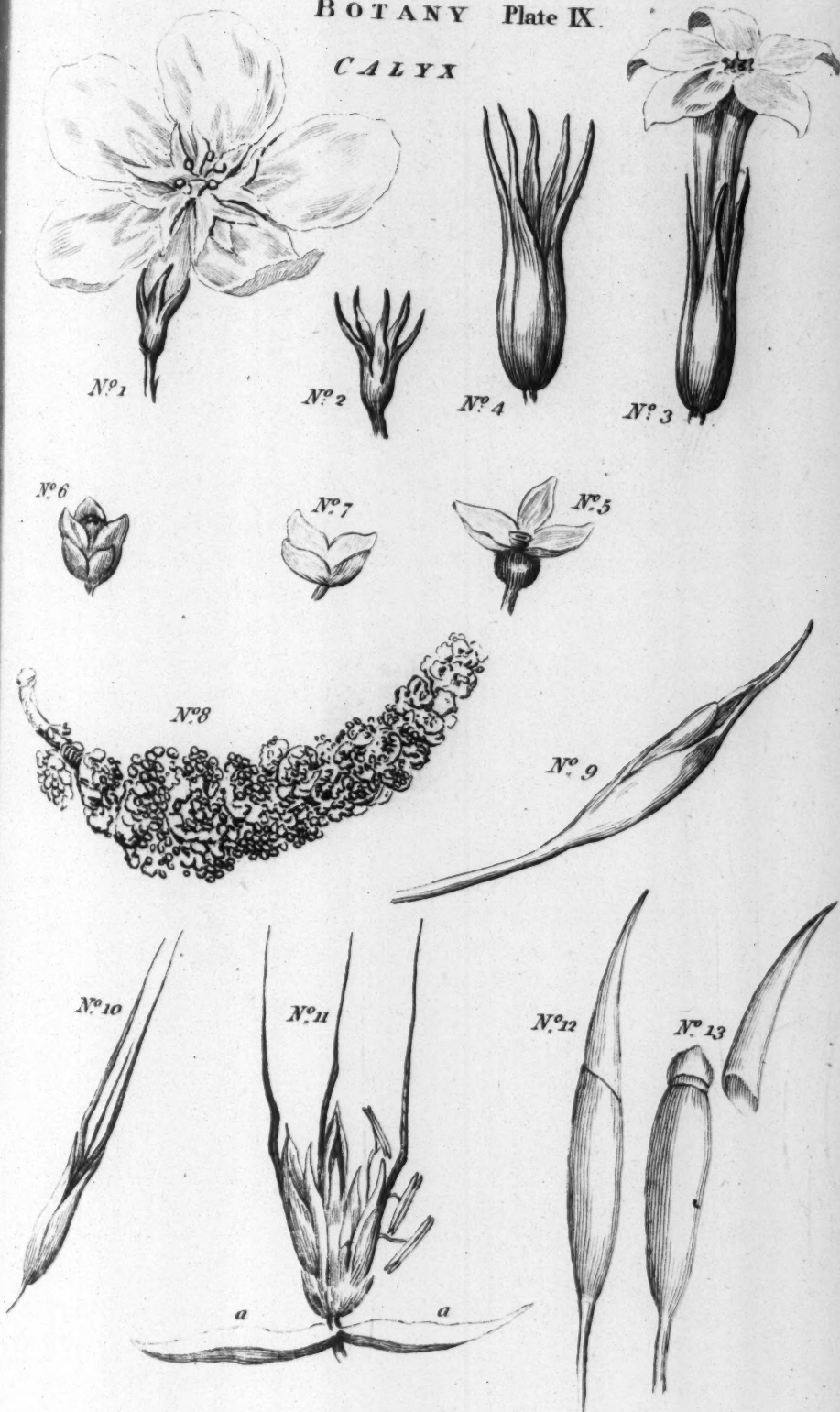
a, a, an universal involucre.

b, b, a partial involucre.

PLATE

BOTANY Plate IX.

CALYX

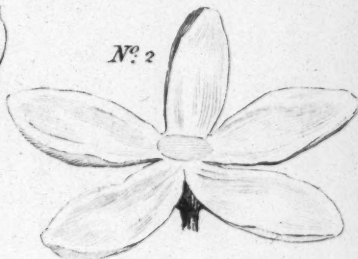
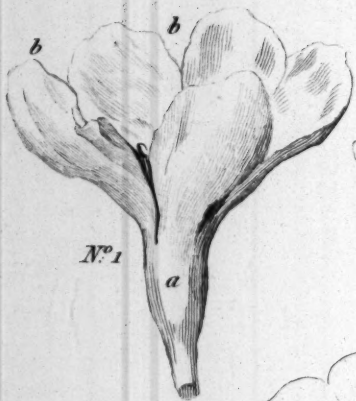




ROBERTA 1897



BOTANY Plate X.



COROLLA

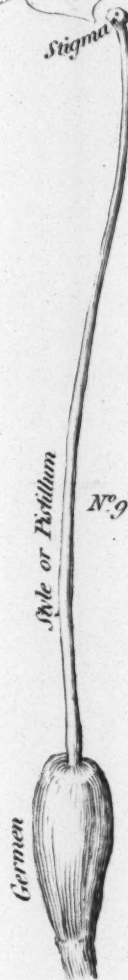
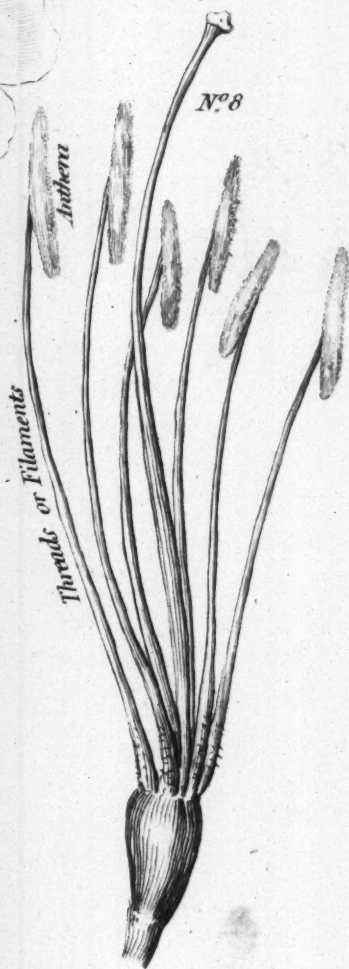
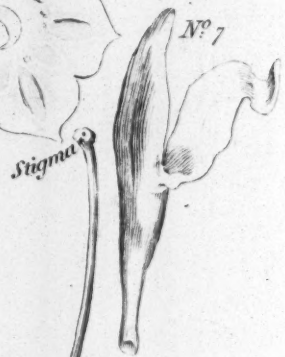
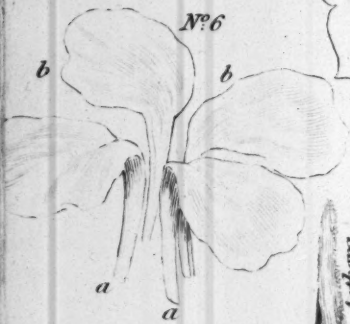


PLATE X.

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ILLUSTRATIONS OF THE COROLLA.

No.

1. The flower of the *Oleander*, separated from its calyx: the corolla consisting of a single petal only, *monopetalous*, funnel-shaped: the tube, *a*, *cylindrical*: the limb, *b, b, b*, large: divided into five parts, *quinquefid*.
2. The *Orange-flower*: the corolla consisting of five petals, *quinquepetalous*.
3. *Campanula*: a bell-shaped flower. *N.B.* No tube.
- 4, 5. The *Kalmia*: A specimen partly *salver-shaped*, *hypocrateriform*. Seen in front and back.
6. The *Stock July-flower*, the corolla *cruciform*. *a, a*, the claw (*unguis*) of the petals; *b, b*, the *lamina*, in a flower of several petals, answering to the *limb* in a flower of a single petal.
7. *Oswego tea*: a gaping petal, *ringent*. See the *common Nettle*.

.....

ILLUSTRATIONS OF THE STAMEN.

8. Shows the *stamen*, or male part of the *Amaryllis*, *i. e.* the threads, or filaments, the antheræ containing the meal, or pollen, *farina*.
9. Shows the *pistillum*, or female parts of the same plant, separated, *i. e.* the germen, the style or pistilum, the stigma.

PLATE XI.

.....

ILLUSTRATIONS OF THE PERICARPIUM.

No.

1. The fruit-vessel, *pericarpium*, of the *canna*, or *Indian flowering-reed*. See plate IX, No. 5, having on the outside three furrows, *trifurcate*.
- 2, 3. The same, cut open, showing the internal structure, having three cells, *trilocular*; and three valves, *trivalvular*.
4. A *conceptacle*. A single valve, the seeds not fastened to it.
5. A cone, *strobilus*; the instance is the *Scotch fir*.
6. Shows how the seeds adhere to the receptacle.

ILLUSTRATIONS OF THE SEEDS.

7. The general external appearance of a seed: *a*, the scar, *hilum*, where it was fastened within the fruit.
8. A seed opened: *a*, the descending root, *caudex*; *b*, the ascending root, *plumula*; *c, c*, the side lobes, *cotyledons*.
9. A winged seed.
10. A downy seed.

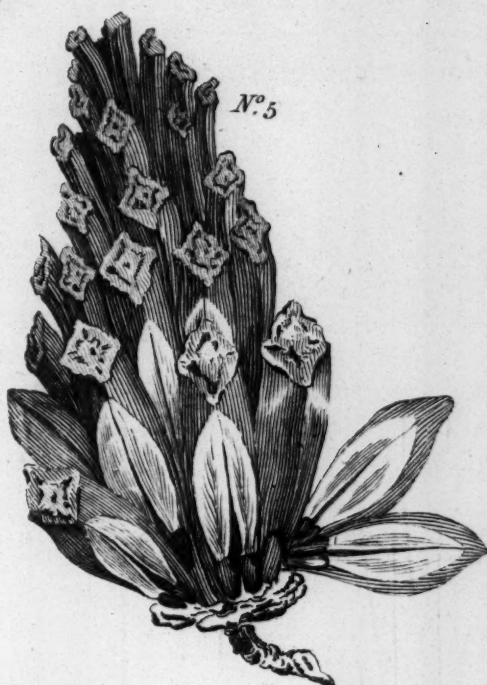
N.B. Wings, down, &c. are for the purpose of assisting to disperse the seed by flying, &c.

PLATE

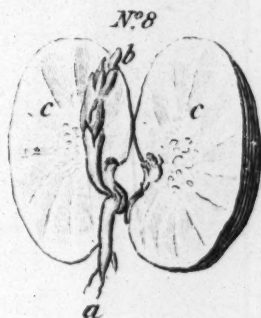
BOTANY Plate XI.



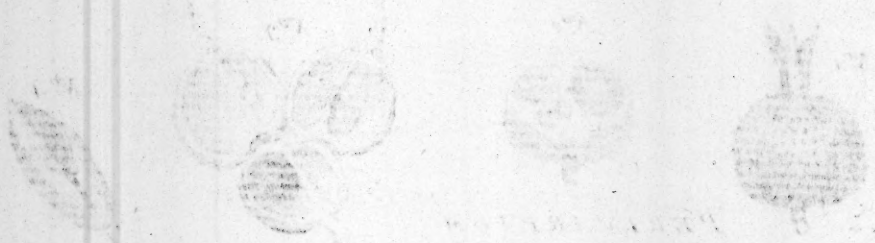
PERICARPIUM



S E E D S



LIBRARY OF THE



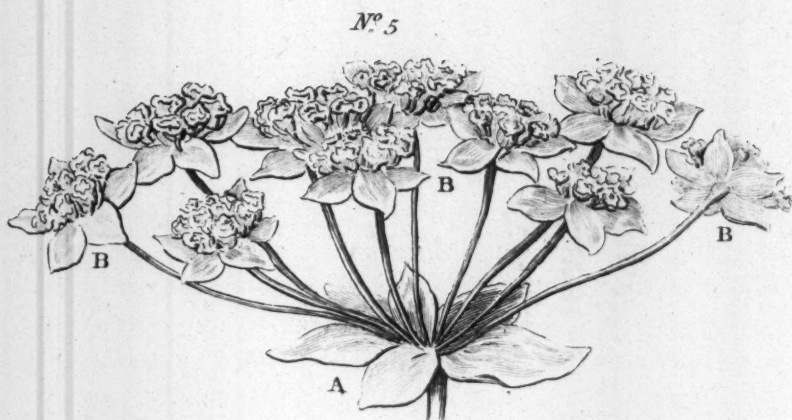
BOLEBY PLATE XII

WATERWORKS



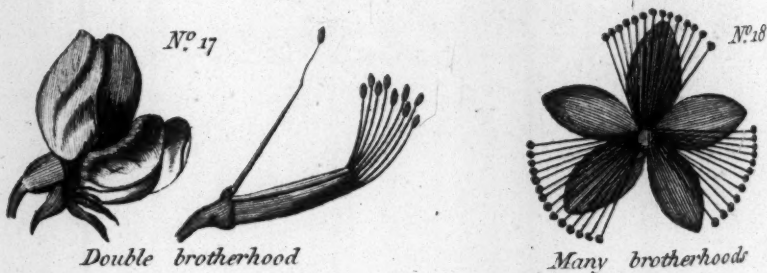
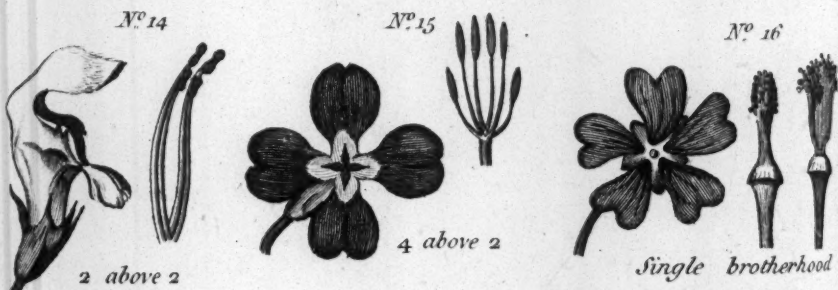
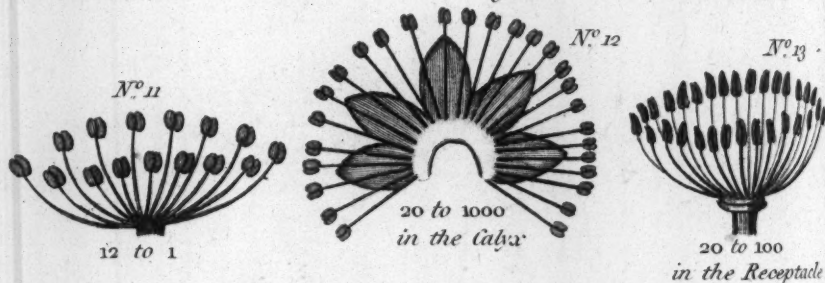
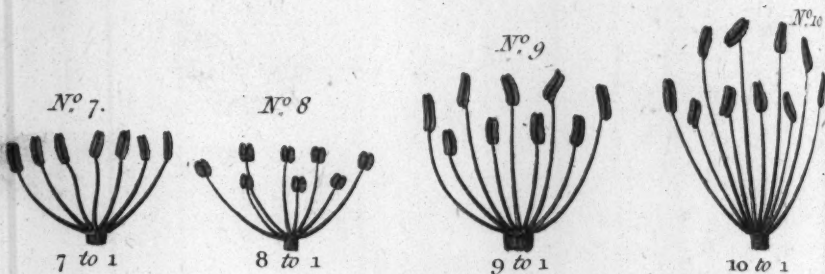
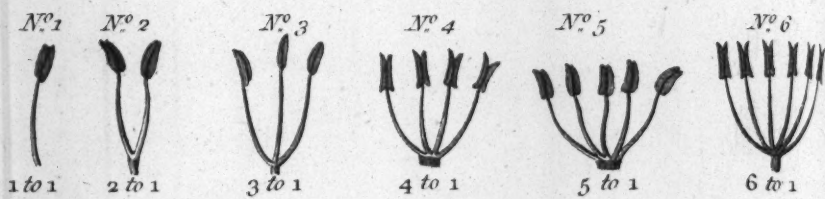
BOTANY Plate XII.

RECEPTACLE





BOTANY Plate O.



P L A T E X I I .

ILLUSTRATIONS OF THE RECEPTACLE.

No.

1. The common *Bramble*; showing a conical receptacle, on which the fruit grows naturally.
2. The fruit separated from the receptacle; showing the orifice which formerly received the receptacle.
3. A receptacle of the seeds; the common *Butter-flower* of the meadows.
4. A common receptacle: the florets seated regularly upon it. The *Dandelion*.
5. An umbel, or number of footstalks rising to an even surface at top. *Bupleurum*.
A. A general or universal umbel.
B. A partial umbel.
6. A simple umbel, having no subdivision. *Androsace*.
7. A *cyme*; a number of long fastigated footstalks, rising from the same centre; a secondary number of smaller footstalks rising from the top of the former, irregularly dispersed: but both universal and partial footstalks rising to an equal height: as in the *Viburnum*.

P L A T E X I I I , marked (O).

LINNÆAN SYSTEM, PLATE I.

The student has already seen, page 49, 50, the general plan of the Linnæan system, in the tables of the classes and orders.

This plate will recall to his recollection that the first eleven classes are reckoned by the number of the antheræ, and are named accordingly.

(Refer to page 57, and peruse the remarks.)

12. The stamen inserted into the calyx; which is the specific distinction of this class.
13. The stamen inserted into the receptacle.

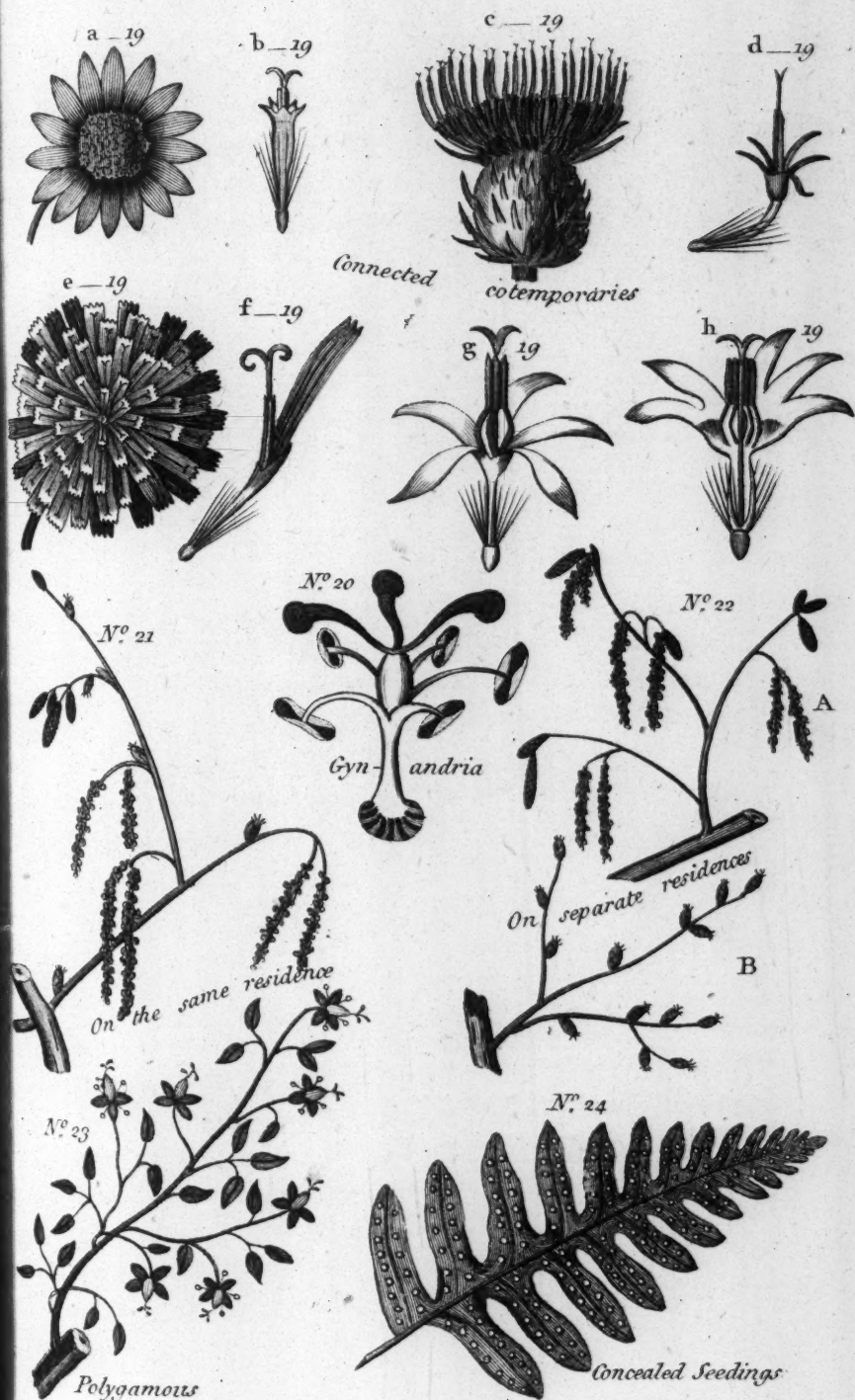
14. Two

14. Two of the stamina are clearly seen rising above two others beneath them: this is a strong and natural distinction.
15. In the same manner, four stamina are here seen rising above two.
16. Single brotherhood.
For this and the following see the REMARKS, p. 51.
17. Double brotherhood.
18. Many brotherhoods.

PLATE XIV, marked (P).

LINNEAN SYSTEM, PLATE II.

19. *a*, shows the flower in its natural state.
b, shows one of the centre florets of fig. *c*, separated from the general association, for the sake of greater distinctness.
c, shows the florets combined into one flower.
d, shows one of the florets, its external covering being taken away.
e, shows another flower of this class, in its general appearance.
f, g, h, shows one of the florets separated from the general flower, and cut into a section, for the sake of greater distinctness.
20. Gynandria, *vide* REMARKS, p. 51.
21. Male and female flowers, on the same plant.
22. Separate residences for the different sexes of the flowers; the males on one plant, the females on another.



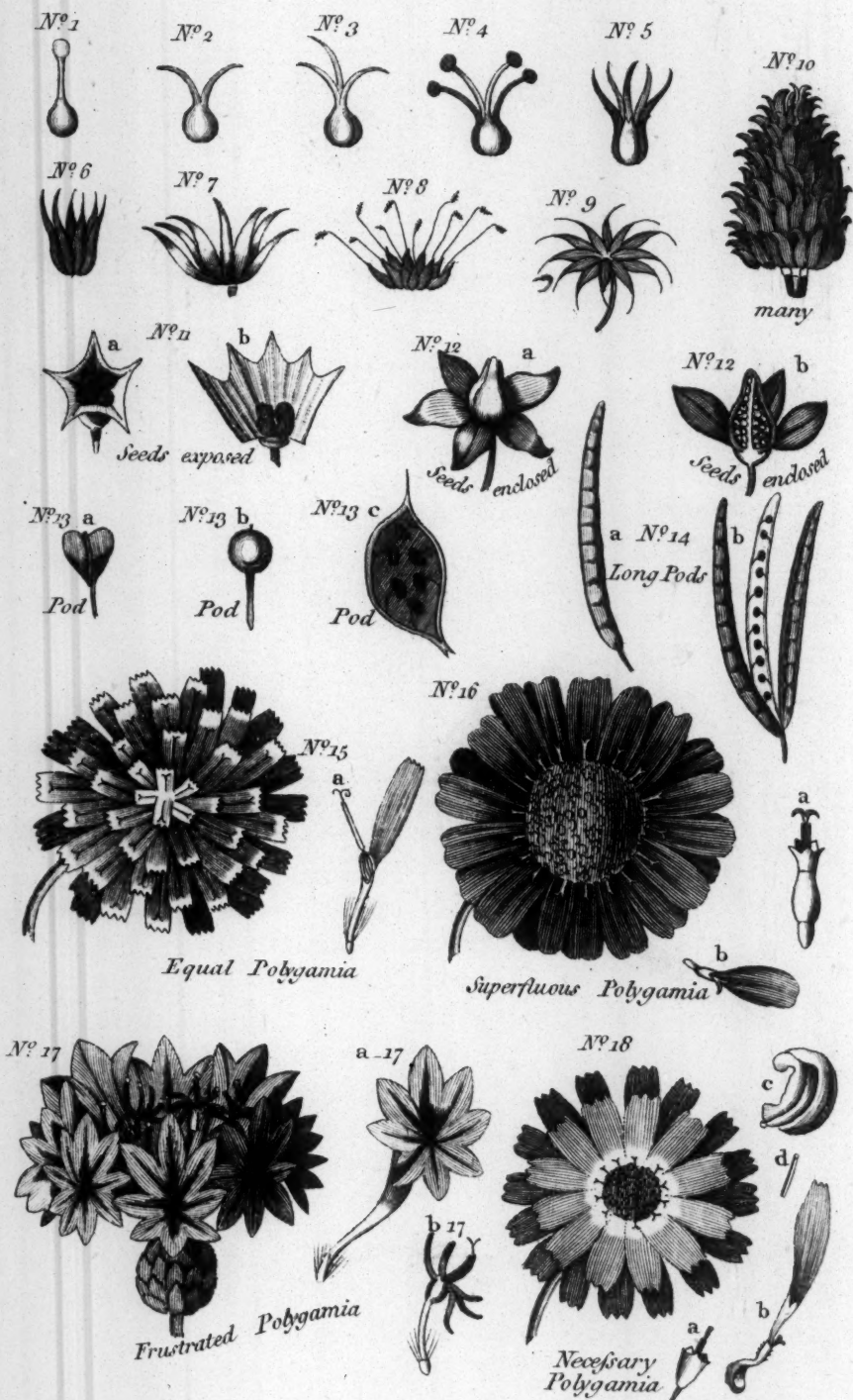


PLATE XV, marked (Q).

LINNEAN SYSTEM. PLATE III.

(Vide the Remarks on the Orders, p. 52.)

The first ten numbers of this plate being arranged by the number of their styles, are extremely simple, and easily carried in the memory.

CLASS XIV, No. 11. *a, b, b*, are the sections of the flower of the *gymnospermia*, or naked-seeded class, and shows the seeds naked as in the flower; which is a distinction founded on nature.

12. *a, b*. *a* shows the covering case of the seeds in the flower: *b* shows by a section of the flower and of the case of the seeds, their true situation within the case.

13. *a, b, c*, show the short, thick, or round pod, which perhaps had better be called a *cod*, to distinguish it from the following number; and shows the situation of the seeds.

14. A long pod; *c* shows the external form of this pod; *b* shows the situation and places of the seed which it incloses.

CLASS XIX, No. 15. *a* shows *equal polygamy*. Vide REMARKS, p. 52.

a is a floret shown separately for greater distinctness.

16. *Superfluous polygamy*, vide the REMARKS. *a, b*, separate florets; *a* hermaphrodite, *b* female.

17. *Frustrated polygamy*. *a* shows a neuter floret, *b* an hermaphrodite floret.

18. *Necessary polygamy*. *a, b, c, d*, parts of the florets shown separately.

PLATE

PLATE XII, marked (R).

LINNÆAN SYSTEM, PLATE IV.

CLASS XIX, No. 19. *Segregated polygamy*. *a, b*, florets separated from the foregoing flower.

20. *Monogamous polygamy*. *a, b*, the parts shown separate.

22, 23. Ferns.—24, 25. Mosses.

.....

In reducing these principles to practice, the student having plucked a flower is directed to see first what is its proper class, then to determine its order. The classes being known by their antheræ, let him count the number of those parts; if they agree to any of the first eleven classes, and the flower be hermaphrodite, the number,—as two, four, six, &c. denotes the class, *diandria*, *tetrandria*, *hexandria*, &c. if the flower have several styles also, then the number of these denotes the order—thus a flower of the *diandria* class, *i. e.* having two antheræ, may be of the *digynia* order, by having two styles; or a flower of the *hexandria* class, *i. e.* having six antheræ, may be of the *tetragynia* order, *i. e.* having four styles.

But if the antheræ are many, *i. e.* above twelve, then see whether they be inserted in the calyx, or on the receptacle, and range the flower accordingly: this requires attention.

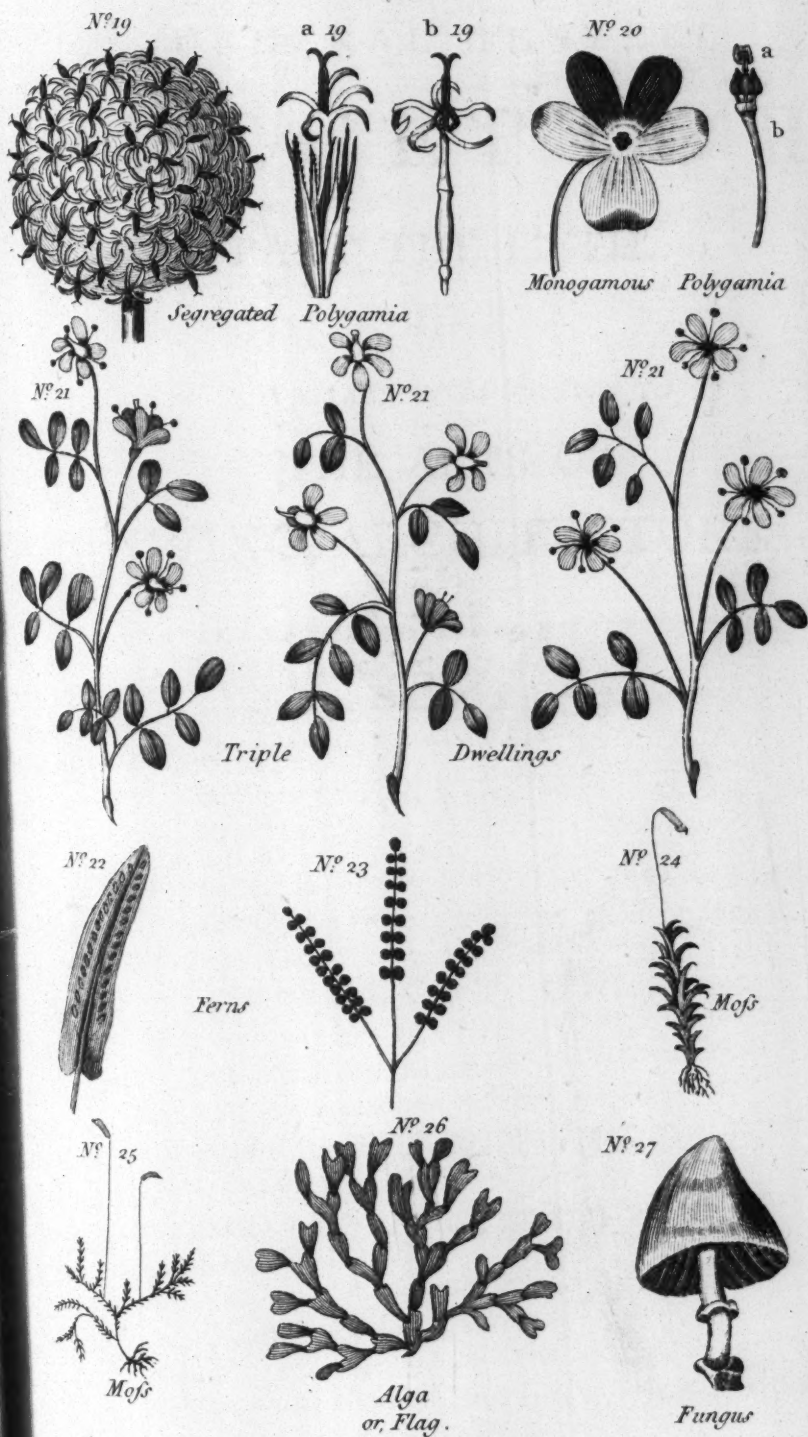
The classes two above two, and four above two, are not difficult, being a truly natural class of flowers: and not likely to be assimilated to any other.

The brotherhoods are pretty clearly denoted, especially the *carinated*, keel-shaped, flowers.

Class XIX is troublesome, owing to the orders; but a little inspection will enable the student, to a certain degree, to arrange their orders by observing the nature of the florets; which will appear upon dissection. The whole class being compound flowers, cannot easily be mistaken.

The other classes and orders will be readily distinguished by a little attention to their peculiar marks.

END OF THE BOTANICAL PRECEPTOR.





THE
GENERAL GENTEE
PRECEPTOR:
PART THE FIFTH.
BEING
A SUMMARY INTRODUCTION TO
THE ARTS OF
DRAWING, ARCHITECTURE, &c.

ADAPTED TO THE SERVICE AND INSTRUCTION OF
YOUTH OF BOTH SEXES;
AND OTHERS,
WHO WISH TO ACQUIRE, OR TO CONFIRM, USEFUL AND PLEASING
KNOWLEDGE IN THE VARIOUS BRANCHES OF
EDUCATION.

BY
FRANCIS FITZGERALD, ESQ.

ADORNED AND ILLUSTRATED BY PLATES.

.....

L O N D O N :
PRINTED FOR C. TAYLOR, NO. 105, HATTON GARDEN.
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THE
GENERAL GENTEEL PRECEPTOR.

.....
PART V.

BEING AN
INTRODUCTION
TO THE PRINCIPLES OF
DRAWING AND ARCHITECTURE.

.....
LEARNING TO DRAW, IS LEARNING TO SEE; FOR THOSE ONLY
CAN BE SAID TO SEE OBJECTS, WHO ARE IN SOME DEGREE
ACQUAINTED WITH THEIR TRUE FORMS, AND THEIR DIFF-
FERENT APPEARANCES IN DIFFERENT SITUATIONS.

.....
THE Art of DRAWING is so extensive, and embraces so
great variety of subjects, that it is extremely difficult to com-
press it within the limits which in this work it ought to occupy:
nevertheless, beside that it is a polite Art, of very general
study, and a most pleasing amusement, it is constantly useful,
and in many cases indispensable. I have known both Gen-
tlemen and Ladies, deeply regret their ignorance of this Art,
when they have seen striking objects, which they wished to de-
lineate; or when they have endeavoured to describe, by words,
articles, which had they been able to draw them, a few lines
would have saved both trouble, and mortification, and would
have given clearer ideas than any verbal Description, how-
ever prolonged or particular. For these reasons I have offered

Part V.

B

a sum-

a summary view of the elements of this Art: whoever wishes to attend more particularly to it, which is a disposition I cannot too much recommend, will meet with copious instructions, both as to its principles, and its practice, in my ARTIST'S REPOSITORY and DRAWING MAGAZINE, of which the seventh Edition is now before the public; and which enters at large into the various branches of the subject.

The foundation of the Arts of Design, should undoubtedly be laid in the Science of GEOMETRY; but as it has been judged proper to *postpone* that branch, for the present, I shall now submit my sentiments in another order.

It may seem strange, perhaps to some, that I should begin this study with the human figure: but, I think the following reasons justify the method. *First.* The human figure is the summit of beauty; whoever has just ideas of its proportions, will always find an advantage in drawing inferior objects. *Secondly.* The figures &c. with which young persons adorn their works, are usually the worst performed in their pieces, which seems to imply—not only their want of information, with respect to their true principles, but also the necessity of a prolonged acquaintance with them, and greater practice. *Thirdly.* The forms, &c. of the human figure are in reality no more difficult than those of any other subject, so far as relates to a general representation of them: for instance, what forms can be *simpler* than those of the Eye, Plate I. II. or what principles more easy (indeed they are almost mathematically easy) than those of the manner of placing the features, Plates X. XI. Now when these are well understood, and have been frequently repeated, there is no form of a flower or a tree, of a house or an animal, but what will be diminished at least one half of its difficulty of representation, and will acquire a much greater degree of elegance from a Hand and an Eye which has some previous knowledge of a superior subject, than could be imparted to it, by a hand which had attended for *only* an equal time, to such an article alone.

It will be remembered, that I am not speaking of mathematical lines and correctness, but of the principles of elegance, and of the readiest method of attaining a correct eye, and applying its advantages to practice: now, as a smaller error is seen in the representation of a head than would be seen in the representation of a tree, it follows, that for the advantage of detecting errors, the head is the best subject; and detection of errors is the very first step to accuracy of representation. Neither is there any real discouragement attending this method for every error or inaccuracy detected, is in fact a lesson received, and tends to diminish the difficulties in every succeeding subject.

Nevertheless, nothing need prevent the study of the human figure and of other subjects from proceeding at the same time: flowers, for instance, by reason of their pleasing colours, are very agreeable subjects; and our examples of Botany may assist in this study; as are many others, which may very well engage those students, whose time and leisure admits of their union; but where only a certain portion of time and convenience can be bestowed, undoubtedly that branch of Art which the mind will most *firmly* retain and which is likely to be of most *lasting* benefit is, an acquaintance with the general principles of the human figure.

It will be recollected too, that it is on this subject, judgment and opinion are most liable to err; that when pictures &c. are submitted to inspection, remarks on the figures they contain are usually less accurate and less estimable than those which are made on other parts of the piece. An endeavour to correct this evil needs no apology.

We now wish to lead the student, lesson by lesson, into this polite accomplishment: for this purpose we advise him to take up the first plate of EYES; to trace the forms of a *single* example in *outlines* only: and to repeat this, till he has acquired an intimate acquaintance with it.---Then let him shut up the

example; and, without seeing it, trace upon paper the outlines of those forms which he has just studied: compare this production of the memory, to the original, and correct it where wanting. Proceed thus repeatedly. Let this suffice for one morning's exercise, repeat it, or not, a second morning according to circumstances. In the same manner, trace a second example; and so of the others.

Having thus acquired a strong and distinct idea of the forms of the Eye, proceed by the same method to acquire equal familiarity with the Nose, the Mouth, and the Ear. By this time, some readiness of handling *must* be acquired, as well as considerable correctness of the Eye; and now the insertion of the shadows &c. may be attended to with advantage; but even these should be treated *gradually*; the chief shadows first, lightly, contractedly, and, at length, to their full proportion and power.

We cannot too much insist on the necessity of well understanding these parts *separately* before they are united in the head: for this reason, we have given them *at large*, that they may be the better understood, and imitated, as well as to contribute to freedom of hand. But in order to avoid multiplying our plates, we have inserted the mode of placing the features of the face, in several examples, on one plate, and of a diminished size: And she rather because by readily comparing one with others, the variations occasioned by aspect, &c. are more clearly discovered, and as these are of the greatest consequence, the student cannot pay them too much attention; nor can he too well comprehend their principles, and effects. Nevertheless, we *insist* that each of these heads be drawn much larger than they are given, say four, or six times, larger, or as large as Plates XI. to XIV. and treated as we have just directed for the Eye, slowly, and repeatedly, till strong and distinct ideas are obtained of their general appearance, and variations.

The following subjects from Plates XI. to XIV. are given

DRAWING

given, not only as pleasing varieties, but because by their slight shading, they contribute to form the hand of the young designer; and I would not by any means have any of the heads copied smaller than the size of these.

It will be remarked, no doubt, that the proportions of all features are not alike; that no two faces appear to be cast in the same mold; and that many causes contribute to that variety which we observe in the human Countenance. What these causes are, I have treated in my larger work: I shall therefore only observe here, that however the application of these principles may be varied by their subjects, yet the principles themselves remain the same; and though the face of a British lady and that of a Negress may very widely differ in appearance, yet to draw either of them, an acquaintance with the principles we have laid down, is absolutely necessary: and that, in fact, they must be well understood, before they can be respectively applied with judgement, or be more or less deviated from with success. The same reasons apply to Character of every kind of proportion, or of feature.

The *Proportions* of the figure, though examples possessing but a very moderate share of gracefulness, yet possess a great proportion of usefulness. These should be well investigated: and should be strongly committed to memory by frequent study, and consideration.

There is a memory of the Eye, which is equally strong with that of the Mind, and after the Eye has been accustomed to correct itself, and to advert to just proportions, it will not easily bear gross disproportion; it will regard as accurately the calculation of distances and spaces, as the mind does the calculation of numbers and quantities. Hence arises in great measure, the utility of an acquaintance with the Arts of Design, even if never practised; because they lay the foundation for a better judgement, and a truer estimate, of many things, and their circumstances, than can possibly be obtained without such acquaintance.

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The *Attitudes* of the figure, are sketches, designed to be repeatedly drawn on a much larger scale than they are here given; and we advise that each should be taken separately, and copied, at least the size of the measured figure, Plate XV.

I think I may venture to say that the student will have acquired by this time a pretty correct Eye, and a steady hand, and, beside these advantages, he will possess such an insight into the chief proportions, and principles of the figure, as will not only *open his mind* to further instruction, but they will fix themselves on his memory, and will have their influence on his practice whatever subject he may afterwards undertake.

That Mind which has had the advantage of correct principles, and of general information, will find little difficulty in varying its attention according to circumstances as they arise: that Eye which has been used to survey critically one kind of forms, will readily perceive the relation of forms of another kind; and that Hand which has been accustomed to accurate delineation of certain objects, will carry that same accuracy into exercise, whatever be the nature of the objects it is required to delineate.

This summary of Principles, I am certain will be found extremely useful; and it may justly be considered as a favorable introduction to further advances in those who may wish to cultivate a more intimate acquaintance with the Arts of Design.

I shall now offer a few remarks on the practical part of the ART of DRAWING: that some of them are transcribed from the DRAWING MAGAZINE, will be no hindrance to their favorable reception by the public, or their usefulness to individuals.

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OF THE MATERIALS USED IN DRAWING.

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The MATERIALS used in DRAWING are, Pens, black-lead Pencils, camel's-hair Pencils, Indian ink, and India rubber; Chalks, white, red, and black; a T square, a parallel Ruler, and Compasses. Various sorts of Paper are used to work on: for Indian ink, white and fine; for chalk, more rough and coarse; for black and white chalks, blue or brown paper, &c. according to the fancy of the artist.

The use of the black lead pencil is, to form an accurate outline, to be finished in Indian ink; India rubber erases black-lead lines very neatly; the T square, ruler, and compasses, are necessary in drawing perspective, architecture, &c. but should never be applied to figures; the student should learn to see them correctly without such injurious assistance. As a great master expressed himself, "the compasses should be in the eye, not in the hand."

In practising this Art, it is of consequence to have good materials; to purchase those which are but indifferent, is not genuine economy, as they not only give great trouble in working, but they may perhaps occasion disgust with the art, or dissatisfaction with one's self without cause.

In choosing camel's hair PENCILS, moisten them a little, so as to make a true and regular termination; reject those which split into different parts, and those wherein some of the hairs are longer than the proper point.

INDIAN INK is an admirable composition not fluid like our writing inks, but solid like our mineral colours, though much lighter. It is made in all figures, but the most usual is rectangular; about a quarter of an inch thick. Sometimes the sticks are gilt with various devices.

To use this ink, there must be a little hollow marble (to be had at any colour-shop) or other stone, with water in it, on which the stick of ink must be ground, till the water becomes of a sufficient blackness. It makes a very black shining ink; and though apt to sink when the paper is thin, yet it never runs or spreads; so that the lines drawn with it are always smooth, and evenly terminated, how large soever they be. It is of great use in designing, because its tone of colour may be augmented or diminished at pleasure.

23 It is not easy to distinguish the best Indian ink from the inferior; the usual way is by rubbing the stick on the back of the hand, or any other place previously wetted; but frequently the sticks are coated with a fine sort, and the part within is worthless. The makers generally scent the best ink with the best musk.

In using Indian ink it should always be remembered, that a light colour may be darkened by additional washing, but that which is too deep cannot be lightened: the safest and best way is, to proceed gradually from a weak tint, to a stronger, till the various parts obtain the force intended.

WHITE CHALK is a fossil substance usually reckoned a stone, but of the friable kind; it is sometimes found in powder, and has all the properties which characterize calcareous earths, but wants much of the weight and consistence of real stone. Tobacco-pipe clay is commonly used as a substitute for white chalk, and for some purposes is superior.

RED CHALK is an earth of great use, and is common in the colour shops. It is properly an indurated clayey ochre, is dug in Germany, Italy, Spain, and France, but abounds most in Flanders. It is of a fine, even, and firm texture, very heavy, and hard (but when too hard, is troublesome to work with,) is of a pale red on the outside, and of a deep dusky chocolate colour when broken.

BLACK CHALK is a light earthy substance, of a fine black colour, of a compact and laminated texture, and a smooth surface. It is easily reduced into an impalpable powder without injuring its colour: this useful earth comes from Italy (which sort is usually most esteemed) and Germany: but many parts of England and Wales furnish substances nearly if not entirely of the same quality, and equally serviceable both for drawing, and as a black paint.

Notwithstanding the greatest care in selecting the best pieces of chalk they are liable to contain small stones, grit, &c. to remedy which evil, some who are curious in this article, reduce the natural chalk to a fine powder, and (rejecting the refuse) mix with it a composition whose chief ingredient is soap, then roll it into crayons of a proper size, and dry it carefully. Red chalk is much improved by this process.

A variety of PAPER is used in this art: for Indian ink, some use a smooth paper, artificially glazed by heat; others prefer a more substantial kind, the edges of which they paste to the drawing-board, to keep it flat, and prevent its shrinking. For red, or black chalk, there are many various sorts, whole

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names I shall not here repeat. Blue paper is frequently used for black and white chalks, the colour serving for the middle tints of the design, which is shadowed with black chalk and heightened with white. A tinted paper of a brownish hue is sold for the same purpose, but is usually dear in its price. Substitutes are made several ways; by staining white paper with bistre, or with water coloured with tobacco-leaves, or by boiling brewer's clay in beer, and striking it on the paper with a sponge, as evenly as possible.

In respect of attitude, it is worthy of remark, that a good posture is as readily attained as a bad one: an attitude upright and free, is best both for a designer and his works. In fact, this caution respects equally the merits of a performance, and preservation of health.

It is a bad custom to place too near the eye a subject to be copied: when very close, it not only prevents a distinct view of that correspondence of the several parts to each other which is indispensable, but also is not free from danger of rendering the eyes short-sighted. A similar danger attends the admission of a very strong glare of light, either on the original, or copy; a clear steady light, but not too brilliant, is desirable.

Before you begin a performance, consider the original with attention; divide it in your mind into several parts, observe the length, the breadth, and similitude of each part; remark their proportions to each other, and to the whole; their respective distances and situations; more especially attend to those objects or parts which fall perpendicular, or parallel, to others; this rule, duly practised, will prevent material errors.

As the excellence of Drawing consists in its accuracy, endeavour to render the sketch as correct as possible; never proceed to shadow or finish any part of a drawing till the lines of the sketch have obtained a close resemblance to its original; always remembering to begin at the left part of the paper, that the subject may be continually visible; the right side of a drawing, if large, is liable to be injured by the right hand or arm.

It is adviseable to commence the study of this noble art by drawing first in CHALKS (rather than Indian ink,) as they permit a much more bold and free manner of handling, which is a very desirable acquisition.

To begin a drawing in chalks; first form a sketch from the original with a piece of charcoal of convenient thickness and length; this is the best material to sketch with, as it admits of being rubbed out; consequently the outline may be rendered very correct before it is finished. Always hold the port-crayon
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further from the point than the pen in writing, that it may not impede freedom of hand.

Having formed an accurate outline, proceed to finish it by lightly touching the darkest shadows with a few strokes of chalk: these being inserted distinctly, though faintly, proceed to the next darkest, and so on, till all the principal shades have been attended to; then bring the deep ones nearer to their proper colour, which will enable you to form a judgement of the strength requisite for the middle tints. It is necessary to begin shadows first, lest the middle tints, which are the chief beauty in all drawings, should acquire too much colour, and thereby spoil the whole.

Remember to draw the chalk always the same way on the paper (whether from left to right, or from right to left), that it may make a smooth, neat, and uniform grain.

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LIST OF PLATES, AND ORDER OF STUDY.

Plate I. Eyes at large. The Eye seen in Front divides into three parts; the center is the size of the sight, and the proper opening of the Eye. The other examples are different views of the Eye.

Plate II. The Eye in profile, is only half the dimensions of the Eye in front: being one part and half. The other examples are different views.

Plate III. Noses at large: seen in a front view, also from beneath, also from above.

Plate IV. Noses at large, seen in profile; by which it appears that in height and breadth the nostril is about one third of the width of the nose. The Nose seen in front also may be considered as divided into three parts, the *alæ* or wings on each side, and the center. The Nose in front is about equal to the width of the Eye.

Plate V. The Mouth seen in front, is in length about an Eye and a quarter. The Mouth seen in profile, should be nearly half the dimensions of the Mouth seen in front.

Plate VI. This Plate is an example of the beard, and of the situation of the Nose, with respect to the Mouth, &c.

Plate VII. The Ear at large.

Plate VIII. Ears in different views.

The Ear in height rather exceeds one quarter of the height of the head. The width of the Ear is half its height.

Plate

Plate IX. No. 1. In order to place the features of a face seen in front, *first* draw an oval ; as *a, c, e, b, f, d*, this being traced correctly, divide it *perpendicularly* in the middle, as *a, b*, then divide this line *a, b*, in its center, by a *cross line*, as *c, b*, and divide the lower half of the line *a, b*, into *two* parts, by a *cross line* as *e, f* ; the upper half of the oval also divide, by marking in a light touch, for the middle of the upper half of the oval.

No. 2. On the lines prepared as before, proceed to place the features ; *first*, on the intersection *e, f*, placing the Nose, then dividing the space *below* the Nose, into *three* parts, by two markings ; on the uppermost place the mouth : on the cross line *above* the Nose place the Eyes, by dividing the cross line *e, d*, into five parts, and giving one of those parts to each Eye. The two extreme parts rounding off toward the temples seldom shew their whole dimensions. The middle part is for the width of the Nose. Over the Eye place the Eye brows ; and mark the beginning of the hair on the forehead. To complete the head, place the Ear, its bottom about level with that of the Nose, its top rising to the Eye brows. Add the neck to finish the whole.

No. 3. The features being placed as in the former number, suppose the head to be gently turned horizontally, as it were on a pivot ; then so much of one side as is concealed by this motion, will be compensated for by an adequate quantity of the other side being brought into view ; as in this number, the Nose seems to be advanced toward the right cheek, which appears to be diminished, but then a portion of the head from behind the left ear, becomes visible ; so that the general form of the head still preserves the oval ; but the features of the face are removed to one side of the oval instead of being in the middle of it : But their heights on the perpendicular line are not affected by this motion. This is called a *three quarters face*.

No. 4. Shews the features strengthened, the hair, &c. more advanced, and placed to advantage.

No. 5. Supposes the head to be turned so much further from what it appears in No. 2. that now the features are seen *sideways* i.e. in *profile* : the general outline of the head maintains its oval shape ; and the proportions of the features on the perpendicular line are the same as before. This view of the face however differs greatly from No. 2. because the projection of the forehead, the nose, the lips, the chin, and indeed of the whole outline of the face is clearly distinguishable, and their forms are accurately defined.

Plate X. No. 1. In the examples of the former plate the *upright* line of the face suffered no change, because the head was supposed to be moved *horizontally* only, but in this No. the head is supposed to be inclined *downwards*; and all the systematic lines of the face are affected by the motion, and from being straight, become *curves*: as *a, b; c, d; e, f.*

No. 2. Shews how to place the features of the face in the position described above; it appears that the curvature of the lines affects the parts also, and that most of them, as the eye-brows, eyes, nostrils and mouth, assume a correspondent direction; the ear, also, appears to be greatly elevated. As the inclination of the head is downward, in these two examples, all the lines curve downward.

No. 3. In a head looking *upward* the lines of the face have a tendency to curve *upward*; and they assume a direction entirely opposite to that of No. 2. as appears clearly in No. 4. in the eye-brows, eyes, &c. Also, whereas in No. 2. a part of the head *above* the forehead was brought into *view* and the chin was proportionably diminished, in No. 4. the forehead is diminished, and a considerable part of the neck is included in the oval of the head: in this No. also we see *under* the chin, the lips, the nose, the eye brows, &c.

No. 5. Is a profile head looking down. The general rules for placing the features are, to form an equilateral triangle, to divide one face of it into *three* parts; where the lower point indicates the place of the chin, the upper point that of the forehead; the dividing lines that of the nose, and of the eye-brows.

No. 6. The head looking up shews the application of the same principles, only varied in their direction.

These examples may be sufficient to shew the nature of the general variations of the head; almost any motion of the head may be referred to one or other of these; or is more or less compounded of them, and may easily be conceived of from these representations. Nevertheless, as it may contribute to the student's information, we shall suggest an instance which may demonstrate these principles, by mere inspection.

There is a Device which may somewhat assist in forming the face according to its different aspects, and in placing the Features properly thereon. Procure a piece of Box, turned in the shape of an Egg, which is pretty nearly the shape of an human Head. Draw a Line upon it upright, as *a. b.* No. 1. Plate IX. Divide this Line into two equal Parts, by drawing another

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another directly across it at right Angles, as *c. d.*; these two Lines will produce a foreright Face. Turn the Oval a small Matter from the Left Hand to the Right, and the Perpendicular will appear bent like a Bow or Arch, as in No. 3. upon which the Features are to be placed, as usual: incline this Oval downwards; and to the Right, or left: also upwards; to the Right or left &c. A great Variety of Faces may be shewn on this Oval, according as is inclined, reclined, or turned more or less.

Plates XI. XII. These plates shew the variations of the features of the countenance at the different periods of life: the *Child's* head No. 1. Plate XI. is round and fleshy; that of a *Youth* No 1. Plate XII. is more slender: No. 2. Plate XI. is firmer in its lines and general aspect being a *manly* countenance; while the head No. 2. Plate XII. shews the markings &c. which characterize *Old age*.

Plate XIII. XIV. As the former plates shewed the countenance of the Male sex only, these plates shew that of the Female sex: and at the same time, a difference of expression.

Plate XIII. is lively, and chearful; very attentive, and even surprized into admiration, by the object at which it is looking.

Plate XIV. Is respectful and grave; it rather venerates the object of its regards, than admires it: and by the action of its hand laid on its bosom, expresses an internal sensation very different from that of the former plate.

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OF THE PASSIONS, AS RELATED TO EXPRESSION

THE Passions, says M. *Le Brun*, are Motions of the Soul, either pursuing what she judges to be good, or shunning what she thinks hurtful: and commonly, whatever causes Emotion in the Soul, produces some Action in the Body. It is therefore necessary to know what different Actions in the Body express the several Passions of the Soul. But, here, it may be proper to hint at the system of the passions, and their connection with each other; this we extract from Dr. *Watts*.

“ An object which is suited to excite the passions, says he, must have one of these three properties; it must be either,
 “ 1. *rare and uncommon*; or, 2. *good and agreeable*; or, 3. *evil*
 “ and

“ and *disagreeable* ; or at least we must have some such ideas and apprehensions of it, before it can excite any passion in us.

“ Now if we will distinguish the chief passions of our nature according to their objects, and confine ourselves to the common words and names whereby they are usually called, we may make three ranks of them ; which, for distinction's sake, I shall name the first, second, and third rank. The two first are *primitive*, the third is *derivative*.

“ The *first* rank of passions are these three ; *admiration*, *love* and *hatred*.

“ If the object be rare and uncommon ; it excites *admiration* or *wonder*.

“ If we look on it as good, or any way agreeable to us, it may engage our *love* ; but if it be evil or disagreeable, it moves our *hatred*.

“ The *second* rank of chief passions are the divers kinds of *love* and *hatred*, which are also distinguished by their *objects*.

“ If the object appear valuable, it raises a *love* which we call *esteem* ; if worthless, the *hatred* is called *contempt*.

“ If the object appear fit to receive good from us, it is *love of benevolence*, or *good-will* : if it appear rather fit to receive evil from us, the hatred is called *malevolence*, or *ill-will*.

“ If the object appear pleasing, and fit to do us good, it raises the *love of complacence*, or *delight* ; if it be displeasing, and unfit to do us good, it excites a *displacence*, or *dislike*.

“ From *love* and *hatred* in their different kinds (but chiefly from complacence and displacence) arise several more chief passions, which may be called the *third* rank, and which are also distinguished by their objects.

“ *Note*, In this pair of passions, and in all the *third* rank, which is chiefly derived from them, the pleasing object is more properly called *good*, and the displeasing object is more properly called *evil*, than in the passions before mentioned.

“ If the good be absent or unpossessed, and possible to be obtained, the passion of love grows up to *desire* ; if the evil may possibly come upon us, the hatred expresses itself in *aversion*, or *avoidance*. Though there may be also an *aversion* from some evil from which we are sufficiently secure.

“ If there be any prospect of obtaining the absent good, the passion excited is *hope* ; but if the absent evil be likely to come upon us, it raises the passion of *fear*.

“ *Fear* also arises from a present or expected good in danger of being lost : and there is a *hope* of security, from some absent threatening evil, or of deliverance from some evil that is present.

" If the good be actually obtained, or the evil prevented, it
" excites *joy* and *gladness*; if the good be actually lost, or the
" evil come upon us, it causes *sorrow* or *grief*.

" Whoever helps us to attain this good, or prevents the evil,
" excites in us *gratitude*: whoever hinders our attainment of
" good, or promotes the evil, raises our *anger*.

" There are very few, if any, of the passions for which we
" have any name, and which are usually taken notice of in
" the heart of man, but what may be reduced to some or other
" of these general heads. And though I do not pretend to lay
" down this distinction and arrangement of the *passions of man*
" as an uncontroverted or certain thing; yet, upon the best
" survey I can take of the various workings of the heart, as
" well as of the several authors who have written on this sub-
" ject, I do not find any of them lead me into an easier or better
" scheme than this."

It is evidently absurd to pretend to give such particular demon-
strations of the passions as to fix their expressions to certain lines,
which art should be obliged to use as essential and invariable
rules. This would be depriving art of that excellent variety of
expression which has no other limit than diversity of imagina-
tion, which is infinite. The same passion may be finely ex-
pressed several ways, each yielding equal pleasure.

Though every part of the face contributes towards expressing
the sentiments of the heart, yet the eye-brow, according to M.
Le Brun, is the principal seat of expression, and where the pas-
sions best make themselves known. 'Tis certain, says he, that
the pupil of the eye, by its fire and motion, very well shews the
agitation of the soul, but then it does not express the kind or
nature of such an agitation; whereas the motion of the eye-brow
differs according as the passions change their nature. To ex-
press a simple passion, the motion is simple; to express a mixed
passion, the motion is compound: if the passion be gentle, the
motion is gentle; and if it be violent, the motion is so too. We
may observe farther, says he, that there are two kinds of elevati-
on in the eye-brows. One, in which the eye brows rise up in
the middle; this elevation expresses agreeable sensations; and it
is to be observed that then the mouth rises at the corners: another,
in which the eye-brows rise up at the ends, and fall in the
middle; this motion denotes bodily pain, and then the mouth
falls at the corners. In *laughter* all the parts agree; for the eye-
brows, which fall toward the middle of the forehead, make the
nose, the mouth, and the eyes, follow the same motion. In
Weeping, the motions are compound and contrary, for the eye-
brows

brows fall toward the nose and over the eyes, and the mouth rises that way. It is to be observed also that the mouth is the part of the face which more particularly expresses the emotions of the heart: for when the heart complains, the mouth falls at the corners; when it is at ease, the corners of the mouth are elevated; and when it has an aversion, the mouth shoots forward, and rises in the middle.

"The Head," says M. *De Piles*, "contributes more to the expression of the passions than all the other parts of the body put together. Those separately can only shew some few passions, but the head expresses them all. Some, however, are more peculiarly expressed by it than others; as humility, by hanging it down; arrogance, by lifting it up; languishment, by inclining it on one side; and obstinacy, when with a stiff and resolute air it stands upright, fixed, and stiff between the two shoulders. The Head also best shews our supplications, threats, mildness, pride, love, hatred, joy, and grief. The whole face, and every feature, contributes something: especially the eyes, which, as *Cicero* says, are the *Windows of the Soul*. The passions they more particularly discover are, pleasure, languishing, scorn, severity, mildness, admiration, and anger; to which one might add joy and grief, if they did not proceed more particularly from the eye-brows and mouth; but when those two passions fall in also with the language of the eyes, the harmony will be wonderful. But though the passions of the soul are most visible in the lines and features of the face, they often require the assistance also of the other parts of the body. Without the hands, for instance, all action is weak and imperfect; their motions, which are almost infinite, create numberless expressions: it is by them that we *desire, hope, promise, call, send back*; they are the instruments of *threatening, prayer, horror, and praise*; by them we *approve, condemn, refuse, admit, fear, ask*; express our *joy, and grief, our doubts, regrets, pain, and admiration*. In a word, it may be said, as they are the language of the dumb, that they contribute not a little to speak a language common to all nations, which is the language of painting. But to say how these parts must be disposed for expressing the various passions, is impossible; nor can any exact rules be given for it, both because the task would be infinite, and because every one must be guided in this by his own genius, and the particular turn of his own studies."

Plate XV. Proportions of the figure from actual measurement.

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THE MEASURES OF THE HUMAN BODY: FROM FRESNOY.

The Ancients commonly allowed eight heads in height to their figures, though some of them have but seven; but we ordinarily divide the figure into ten faces; that is to say, from the crown of the head to the sole of the foot, in the following manner.

From the crown of the head to the forehead is the third part of a face.

The face begins at the root of the lowest hairs which are upon the forehead, and ends at the bottom of the chin.

The face is divided into three proportional parts; the first contains the forehead, the second the nose, and the third the mouth and chin.

From the chin to the pit betwixt the collar-bones, are two lengths of a nose.

From the pit betwixt the collar-bones to the bottom of the breast, one face.

From the bottom of the breast to the navel, one face.

From the navel to the genitors, one face.

From the genitors to the upper part of the knee, two faces.

From the ankle to the sole of the foot, half a face.

A man, when his arms are stretched out, is, from the longest finger of his right hand to the longest of his left, as broad as he is long.

From one side of the breasts to the other, two faces.

The bone of the arm called *Humerus*, is the length of two faces, from the shoulder to the elbow.

From the end of the elbow to the root of the little finger, the bone called *Cubitus*, with part of the Hand, contains two faces.

From the box of the shoulder-blade to the pit betwixt the collar-bones, one face.

If you would be satisfied in the measures of breadth from the extremity of one finger to the other, so that this breadth should be equal to the length of the body, you must observe that the boxes of the elbows with the *Humerus*, and of the *Humerus* with the shoulder-blade, bear the proportion of half a face, when the arms are stretched out.

The sole of the foot is the sixth part of the height of the figure.

The hand is the length of the face.

The thumb is in length nose.

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The inside of the arm, from the place where the muscle disappears which makes the breast, called the pectoral muscle, to the middle of the arm, is four noses.

From the middle of the arm to the beginning of the hand, is five noses.

The longest toe is one nose long.

The two outermost parts of the nipples and the pit betwixt the collar-bones of a woman, make an equilateral triangle.

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OF DRAWING HUMAN FIGURES.

To draw the human figure at length, first form an oval for the head, then draw a line from the bottom of the head six times the length of that oval.

If a figure stand upright, a perpendicular line from the top of the head to the heel, divides it into two equal parts. The bottom of the belly is the center of the figure. The lower part divided into two equal parts, the middle is the middle of the knee. From the throat-pit to the pit of the stomach, measures one face, which is three-quarters of a head; from thence to the navel is another face, from thence to the lower rim of the belly is a third face.

Remember in whatever you intend to draw, first to sketch its several parts, judging of the distances and proportions, without using the compasses, by your eye, which by degrees will be able to judge of truth and proportion, and will become your best guide. Always begin with the right side of the piece you are copying; for by that means you will always have what you have done before your Eyes; and the rest will follow more naturally, and with greater ease: whereas if you begin with the left side, your hand and arm will cover what you do first, and deprive you of the sight of it, by which means you will not be able to proceed with so much ease, pleasure, or certainty.

In drawing the human figure, first sketch the head, then the shoulders and arms; then the trunk of the body, the hips on both sides, observing their just breadth, &c. then the legs and feet.

Endeavour to form all the parts with truth and just proportion; not one arm or one leg bigger or less than the other; not broad *Herculean* shoulders, with a thin and slender waist; nor raw and bony arms, with thick and gouty legs; but preserving a just symmetry among the members.

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As the human figure exhibits very different appearances in different ATTITUDES, we have thought proper to offer a number of sketches, whose principles may direct the student in his conceptions of their various combinations; and which offer legs, and arms, &c. in many postures.

Plate XVI. No. 1. Is a figure resting pretty much on one leg, laying his hand on his opposite shoulder, proving by this action, that the elbow of that arm is advanced only so far over the stomach as to make a *triangle* with his two shoulders.

No. 2. A man looking at his heels behind him: to do which, he is obliged to bend his knees forward, to bend his loins backward, to bend his neck sideways, and in short to stretch almost every part of his figure. N. B. It appears that so much of the weight of his figure as is thrown forward by his action, is compensated by an equal weight thrown backward from some other parts.

No. 3. This figure shews that the two arms of a man crossed behind his back form a square; and this is the utmost to which he can stretch them, without force.

No. 4. A man carrying a load; wherein observe that so much weight as his load throws on one side, is compensated by the weight of his body thrown on the other side: nevertheless, in moving forward, a part of the weight of his body is thrown forward, to ensure his progress toward that part whither he inclines to proceed.

Plate XVII. No. 1. Shews that the violent exertion or extension of the arm, or of any member, must be compensated by a proportionate weight on the other side of the body.

No. 2. Shews that a lesser exertion, or extension, requires less weight to compensate it: the whole of this figure is more sedate, and in slower progress, than the former.

No. 3. A figure resting on both legs nearly equally; in consequence, this figure is at rest.

No. 4. A figure balancing itself, and to keep itself from falling extending an arm, thereby counterpoising its other parts. N. B. By the impulse from its feet, it can give considerable motion throughout the whole figure with little exertion.

Plate XVIII. No. 1. Is a very violent exertion to throw a dart: proportionate to the violence exerted by the arm, will be the distance which the dart will reach.

No. 2. A cooler and less violent action, consequently the subject thrown will not reach so far as the former.

No. 3. No. 4. Two men pushing and pulling.

Plate XI. No. 1. A man walking against a high wind: shewing, that according to the resistance which he meets from the wind, that

that element, he will protrude his *upper parts*, in order to counterbalance, by his weight thrown forward, the weight of air against which he struggles.

No. 2. A Hercules in the action of striking somewhat below him, in which the elevation of his arm, and of his club, in order for their more rapid descent, deserves notice.

No. 3. A group,—Hercules strangling Antæus: in which Hercules has not only to counterbalance the weight of his adversary, but to resist the impulse of his own exertions in compressing the body of his enemy.

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OF DRAPERY.

IN casting drapery properly and elegantly, many things are to be observed. 1. The eye, must never be in doubt of its object, but the shape and proportion of the part or limb, which the drapery is supposed to cover, must appear; at least so far as art and probability permit; and this is so material a consideration, that many artists draw first the naked figure, and afterwards put the draperies upon it. 2. Nevertheless the drapery must not sit too close to the parts of a figure; but seem to flow round, and, as it were, to embrace them; yet so as that the figure be easy, and have free motion. 3. Draperies which cover parts exposed to great light must not be so deeply shadowed as to seem to pierce them; nor should those members be crossed by folds whose effects are too strong; lest by their too great depths of shadow, the members look as if they were broken. 4. Great folds must be drawn first, and then lesser ones; and great care must be taken that they do not cross one another improperly. 5. Folds in general should be large, and as few as possible. However, they must be greater or smaller, more or fewer, according to the Quantity and Quality of the stuffs whereof the drapery is made. The quality of the wearer, is also to be considered. The drapery of a Magistrate, should be large and ample; that of a country-clown or a slave, coarse and short; that of a lady or a nymph, light and soft. 6. Suit the garments to the attitude of the figure, and make them conform to it; the closer a garment fits the body, the narrower and smaller are its folds. 7. Folds well imagined give much spirit to action; because their motion implies a motion in the acting member, which seems to draw them forcibly, in proportion as the action is more or less violent. 8. An artful complication of folds, in a circular manner, greatly helps the effect of fore-shortenings. 9. Silk and fine linen have little folds and light shadows. 10. Observe the effect of the air or wind upon drapery.

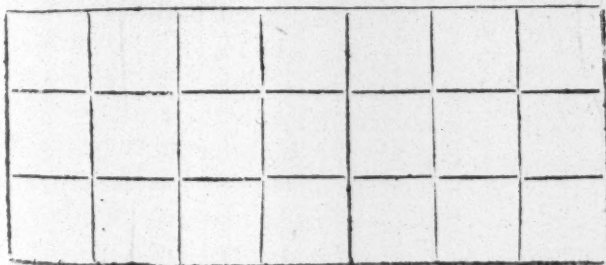
drapery in order to draw the loose apparel all flying one way: 11. Rich ornaments, judiciously and sparingly used, may sometimes contribute to the beauty of draperies. But such ornaments are far below genuine dignity, especially of angels or heavenly figures; whose draperies ought rather to exhibit grace and nobleness, in the folds, than in the fabric of the stuff, or the glitter of ornaments. 12. Light and flying draperies are proper only to figures in great motion, or in a strong wind; but when in a calm, or free from violent action; large and flowing draperies, by their contrast, and the fall of their folds, appear with grace and dignity.

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ON DRAWING LANDSKIPS, BUILDINGS, &c.

THIS is a very useful part of drawing, as it is what every man may have occasion for at one time or another. To be able on the spot, to take the sketch of a fine building, or a beautiful prospect; of any curious production of art, or uncommon appearance in nature; is not only a very desirable accomplishment, but a very agreeable amusement. Rocks, mountains, fields, woods, rivers, cataracts, cities, towns, castles, houses, fortifications, ruins, or whatever else may present itself on our journeys or travels, in our own or foreign countries, may be thus brought home, and preserved for our future use, either in business or conversation.

All drawing consists in nicely measuring the distances and bearings of each part of an original by the eye. To facilitate this, imagine the original to be divided into squares. So far at least as a perpendicular and a horizontal line crossing each other in the center of the picture you are drawing from: then suppose two such lines crossing your own copy. Observe in the original what parts of the design those lines intersect, and let them fall on the same parts of the supposed lines in your copy: I say the supposed lines, because though engravers, and others, who copy with great exactness, divide both the copy and original into many squares, as in the margin, yet this to a student is a very



injurious

injurious method ; and is apt to deceive the learner, who will fancy himself a tolerable proficient, till he comes to draw after nature, where these helps are not to be had, when he will find himself miserably at a loss.

To draw a landscape from nature, take your station at the most favourable point of view, as on a rising ground, where you have a large horizon ; and mark your tablet into three divisions, from the top to the bottom, divide in your own mind the landscape before you, into three divisions also. Then steadily viewing the horizon, keep your body fixed, and draw what is before you ; every thing exactly, with respect to distance and proportion.

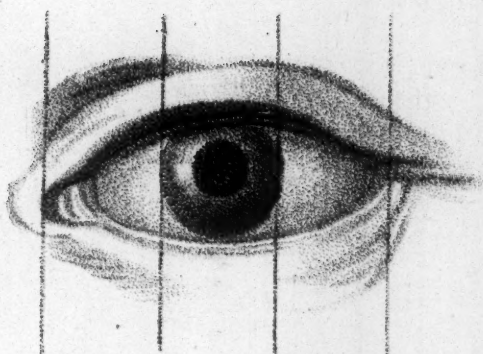
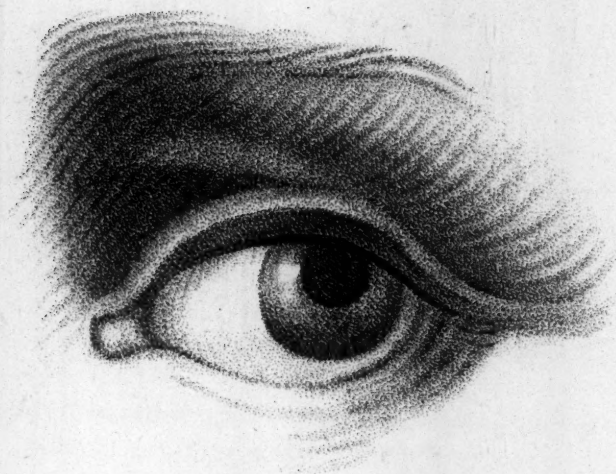
Those are injudicious who make their landscapes mount up higher and higher, as if they stood at the bottom of a hill to take the prospect. Make the nearest objects in your piece the highest, and those that are farther off, lower and lower, till they come almost level with the line of the horizon, lessening every thing proportionably to its distance, and observing also to make your objects fainter and less distinct, the farther they are removed from your eye. Make all your lights and shadows fall one way ; and let every thing have its proper motion, as trees shaken by the wind, the small boughs bending more, and the large ones less ; water agitated by the wind, and dashing against ships or boats ; or falling from a precipice upon rocks and stones, and spirting up again into the air, and sprinkling all about ; clouds also in the air, now gathered with the winds, now violently condensed into hail, rain, and the like ; always remembering, that whatever motions are caused by the wind must be all made to move the same way, because the wind can blow but one way at one time.

As the article landscape is treated at large, and may be had separately by the author of the present work ; under the title of the LANDSCAPE MAGAZINE, we refer to that publication, such of our readers as desire more particular information on this subject.

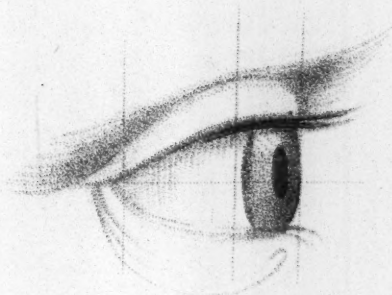
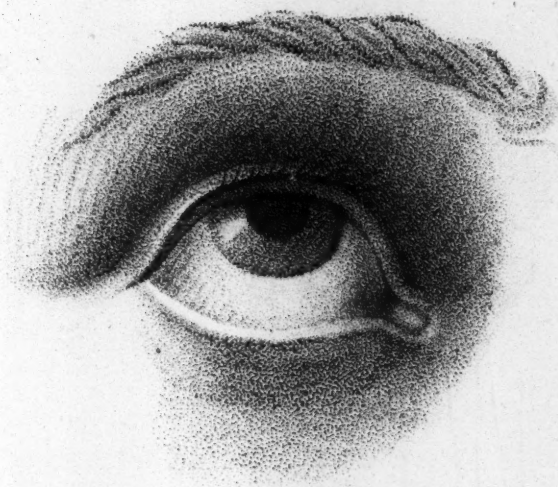
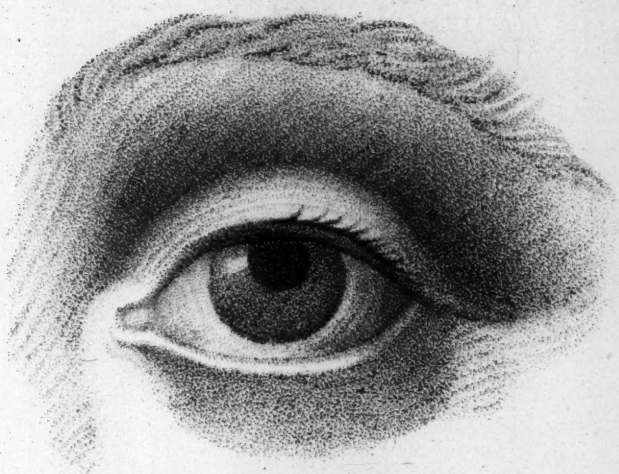


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DRAWING Plate I.



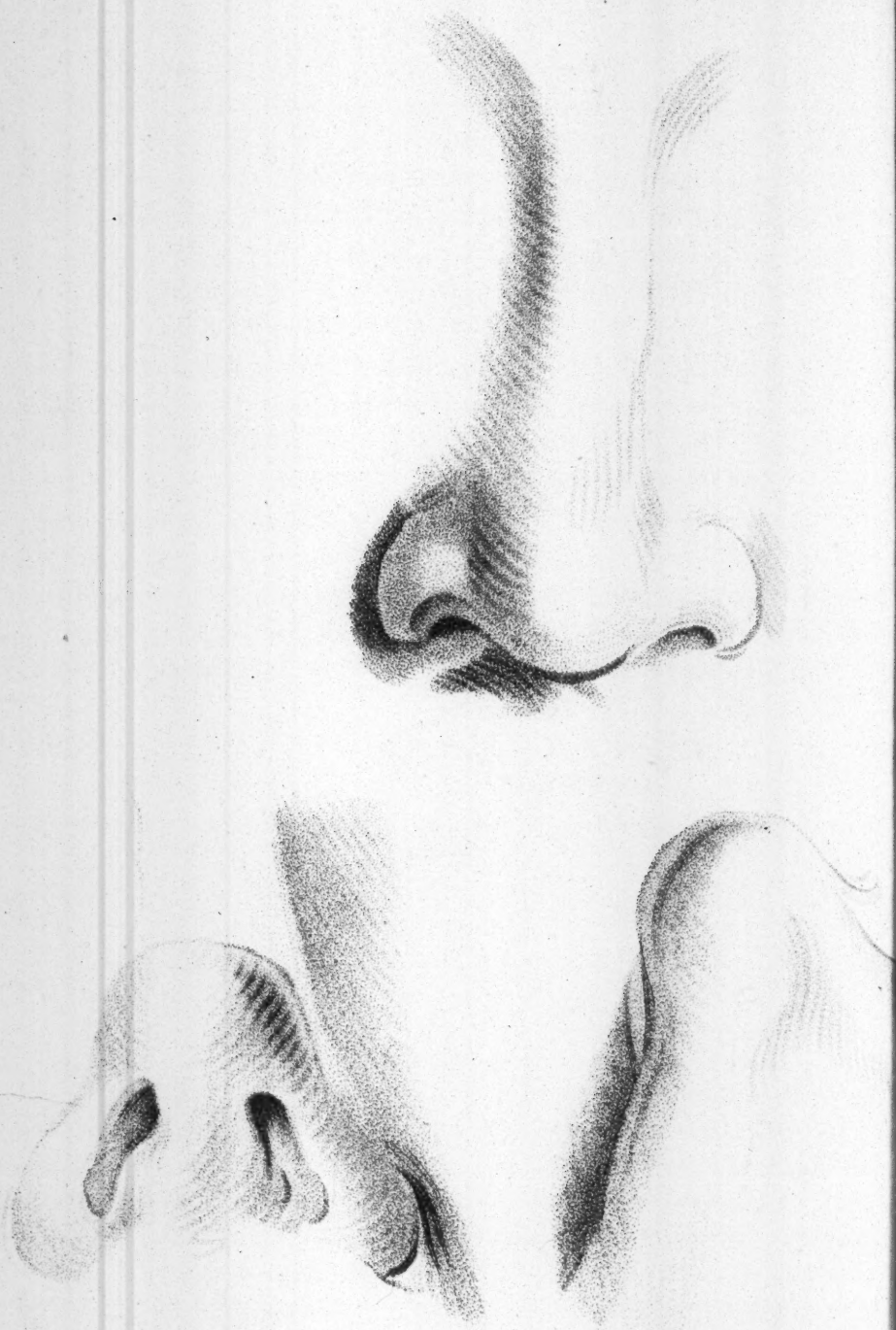
EYES at LARGE.



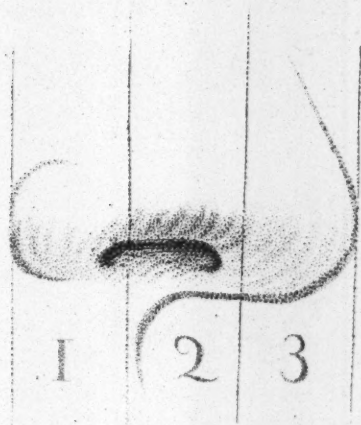
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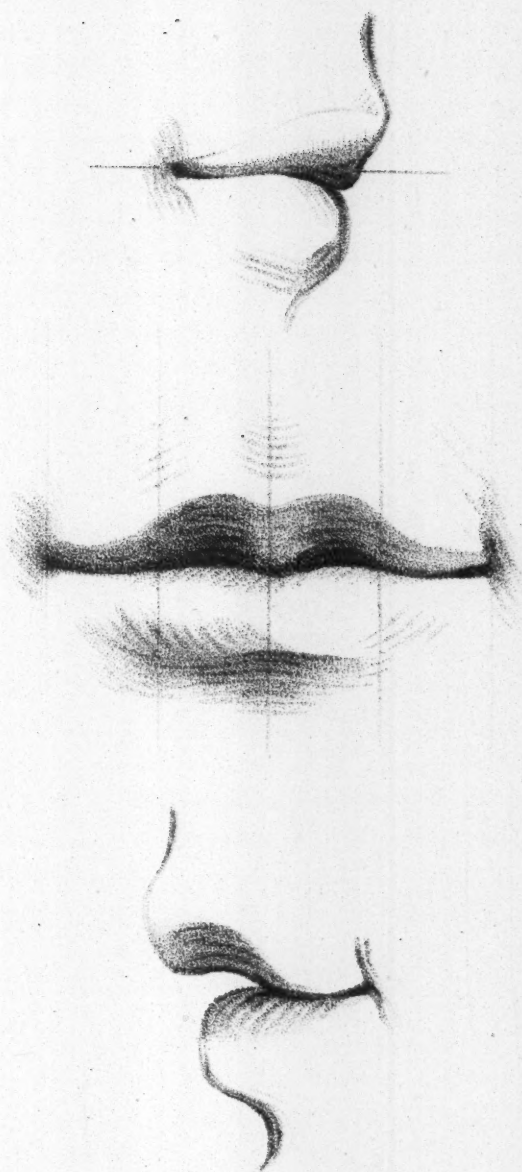


NOSES at LARGE.



DRAWING Plate V.

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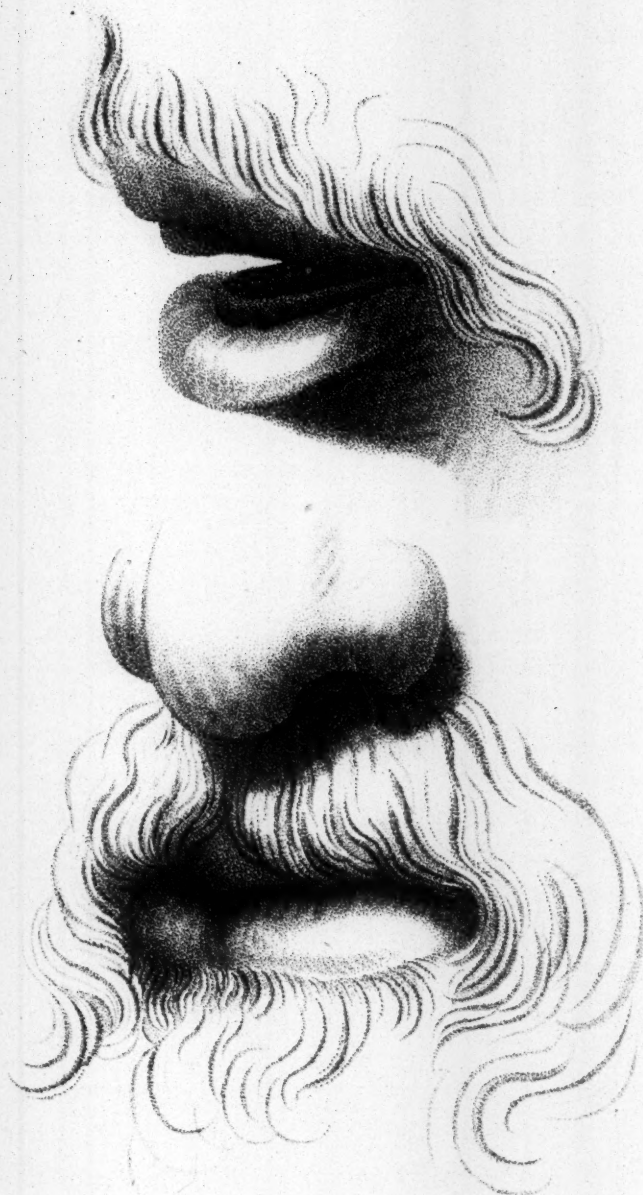
MOUTHS at LARGE.





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DRAWING Plate VI.



MOUTHS at LARGE.



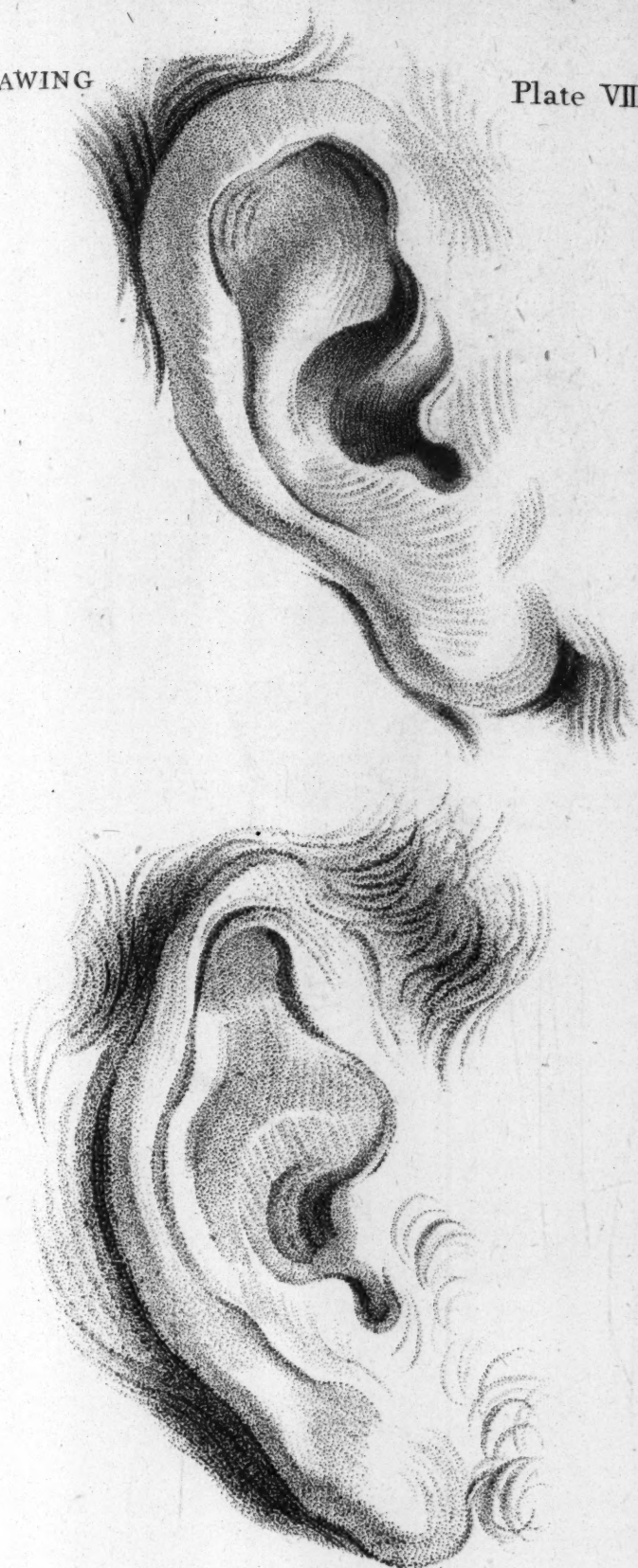


EARS at LARGE.

DRAWING

Plate VIII.

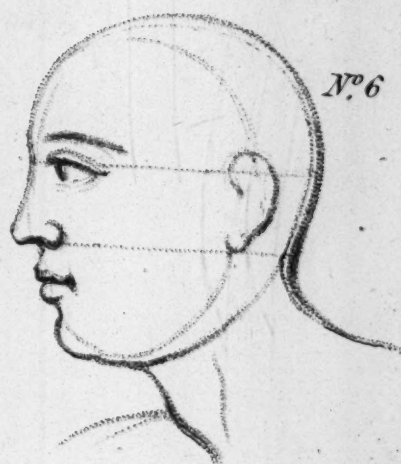
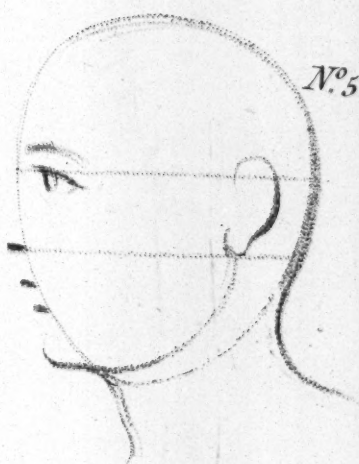
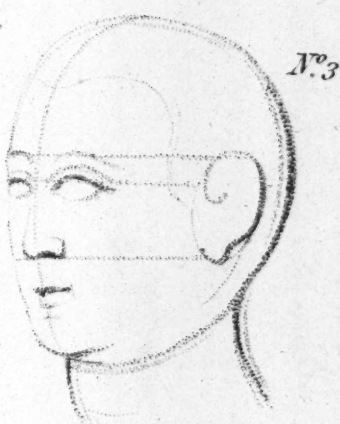
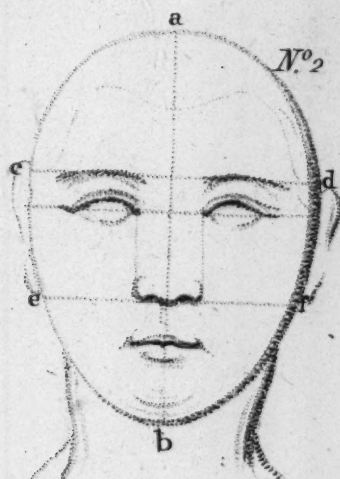
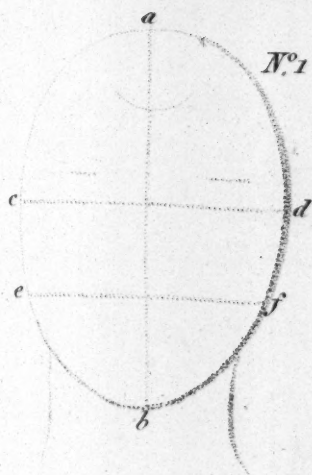
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EARS at LARGE.



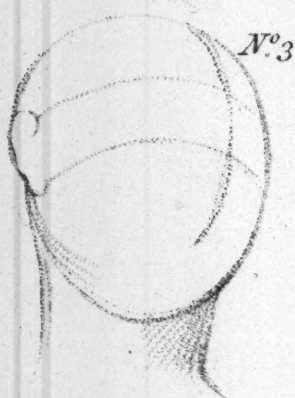
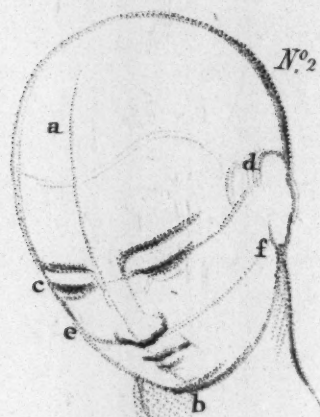
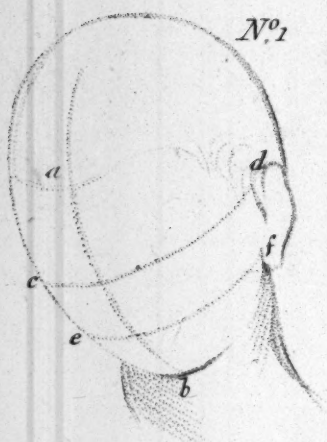
DRAWING. Plate IX.







DRAWING. Plate X.





DRAWING Plate XI.



N° 1.

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DRAWING Plate XII.



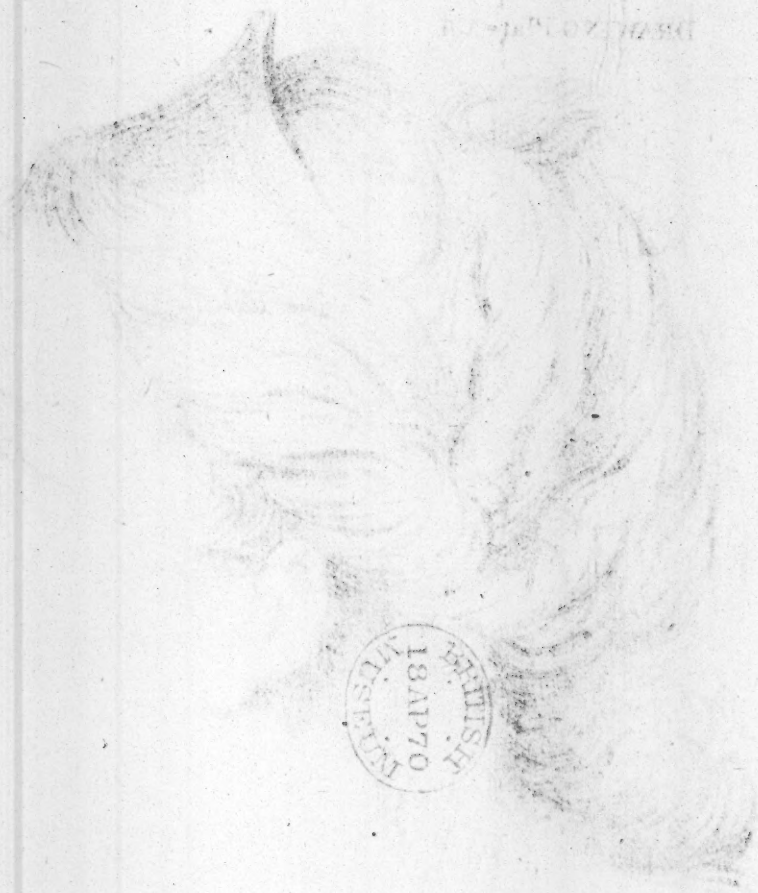
N° 2.

N° 1.



DRAWING. Plate XIII





BRITISH MUSEUM

DRAWING. Plate XIV.





General Preceptor.

DRAWING. Plate XV.

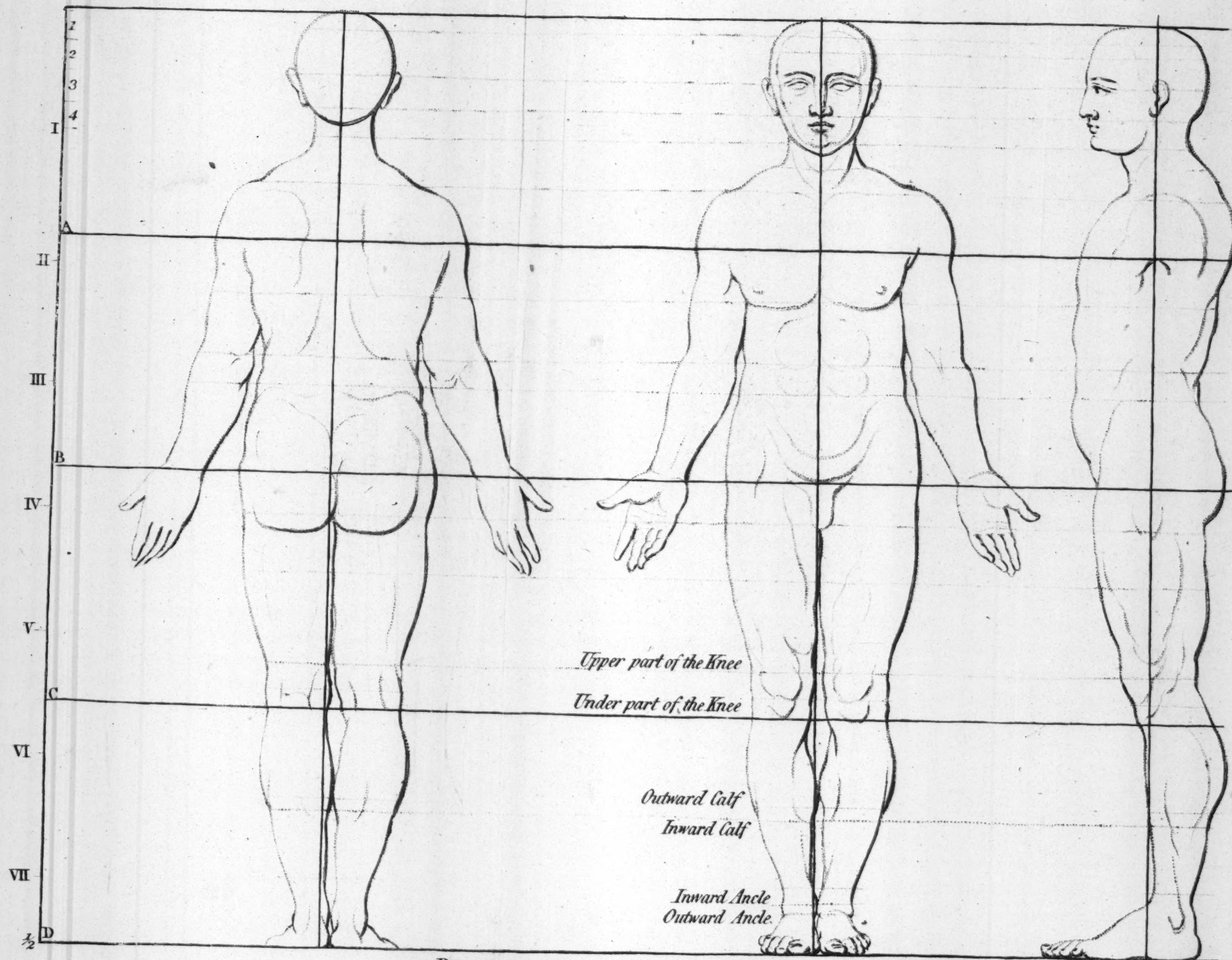


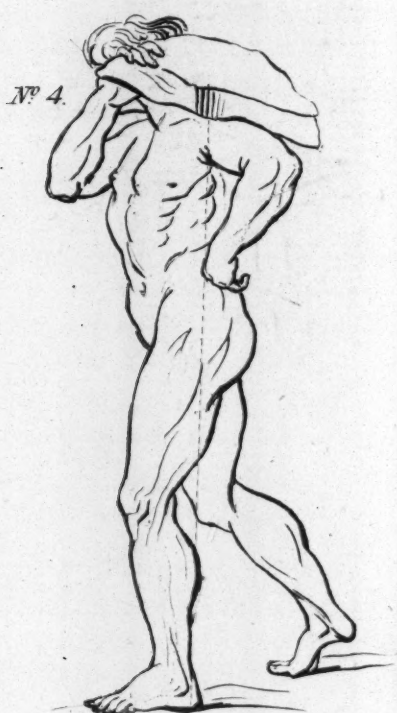


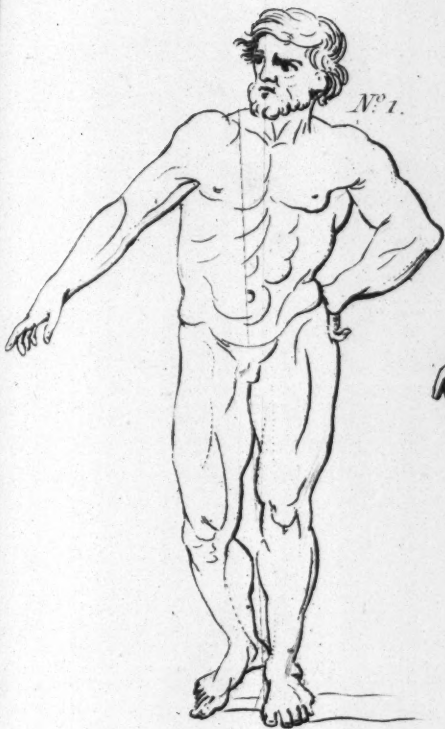
PLATE 10. - FEMALE





ATTITUDES of the FIGURE.





ATTITUDES of the FIGURE.



Fig. 1. 1847.

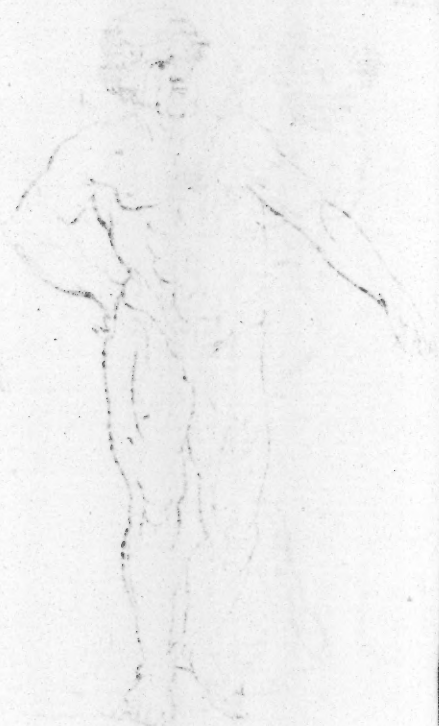
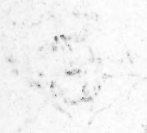
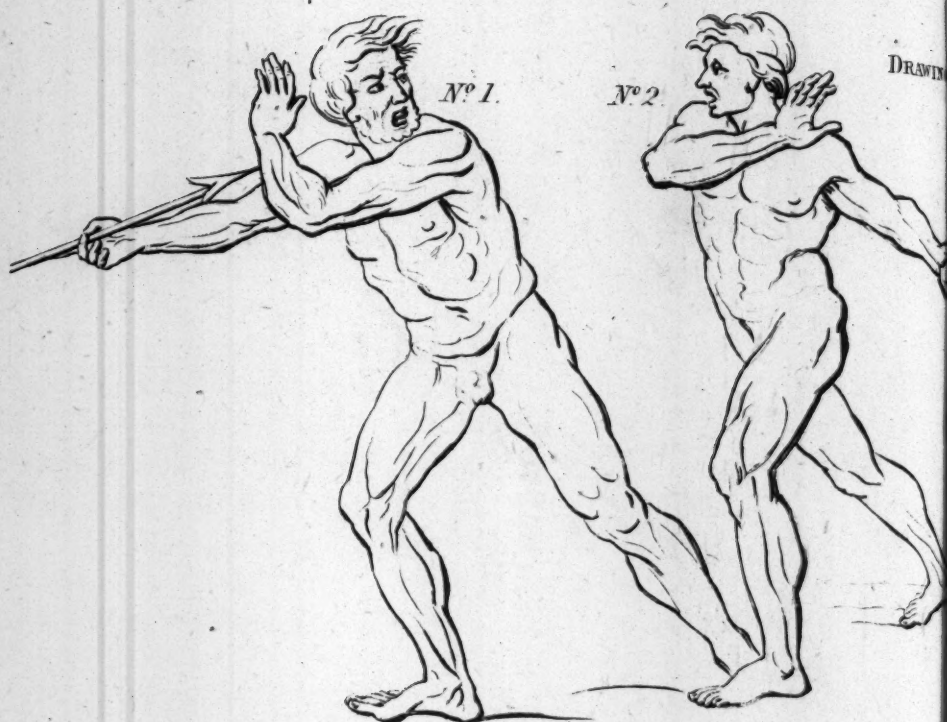


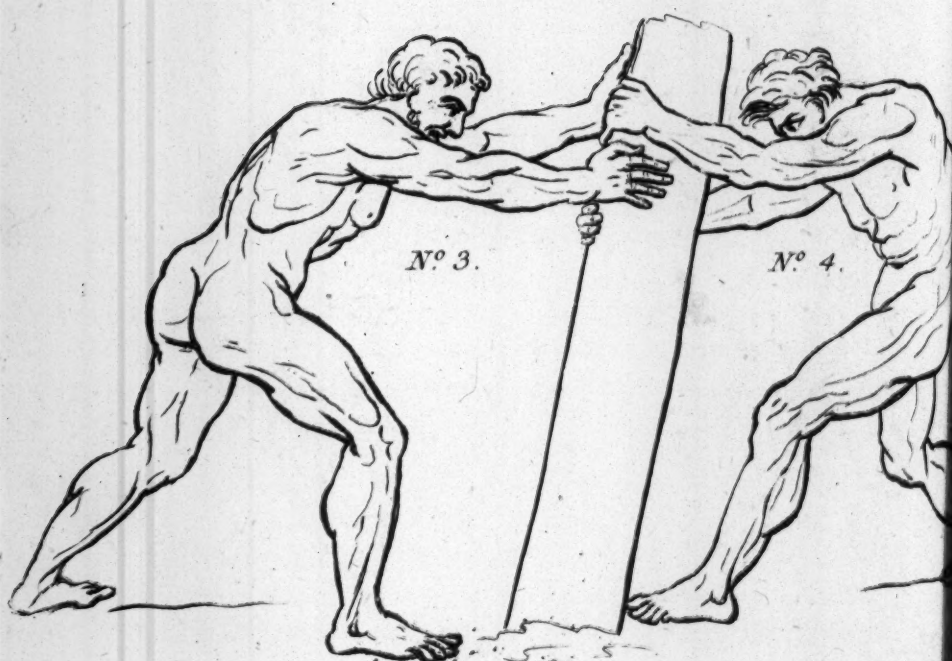
Fig. 2. 1847.







ATTITUDES of the FIGURE.





DRAWING, PL. XIX.

ATTITUDES of the FIGURE.





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INTRODUCTION

TO THE ELEMENTARY PRINCIPLES OF

ARCHITECTURE.

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ARCHITECTURE as a Profession, is so very extensive that it cannot be supposed we design to offer it at length ; yet as it is an art which is constantly presenting subjects for remark, no young person should be suffered to remain intirely ignorant of its general principles ; an acquaintance with these is sure to be wanted in the course of life, and sometimes upon occasions of importance, and by some persons such acquaintance is wanted often ; besides this, as the productions of this art are constantly occurring, it is well worth while to know at least the names of the principal, and of their component parts : it is proper to be able to distinguish the orders for instance, not to call the Doric, Corinthian ; and the Corinthian, Doric—and to name the members rightly, not to call the capital, the base, and the base, the capital ; or an astragal, a hollow, &c.—to distinguish the nature of a plan, a section, &c.—this may possibly be required of the youth who now little thinks of it, but who if he has the initiatory principles of information, will possess a prodigious advantage over total ignorance. Now to correct such ignorance, so far as we can, is the design of the following concise treatise ; if further information is desired, we must, as before, refer to our larger work.

ARCHITECTURE is usually divided, with respect to its objects, into three branches, *civil, military, and naval.*

CIVIL ARCHITECTURE (of which only we treat) called also generally, and by way of eminence, Architecture, is the art of contriving and executing commodious buildings for the uses of civil life, as houses, temples, theatres, bridges, &c.

Nature and necessity taught the first inhabitants of the earth to build themselves huts, tents, and cottages: from which, they gradually advanced to more regular habitations, with variety of ornaments, proportions, &c.

Architecture may be distinguished, with regard to its several periods, into *antique, gothic, modern, &c.* also with regard to the style of the nations where it has been practised, as *Egyptian, Grecian, Roman, Italian, English, &c.*

Architecture has five orders; i.e. of columns, by whose principles the whole of a building is regulated, the definitions *Vitruvius, Barbaro, Scamozzi, &c.* give of an order, are so obscure, that it were vain to repeat them: without dwelling, therefore, on definitions of words, it is sufficient to observe, that of the five orders of columns; three are *Greek, viz. the Doric, Ionic, and Corinthian;* and two *Italic, viz. the Tuscan, and Composite.*

The origin of orders is almost as ancient as human society: the rigour of the seasons led men first to make little cabins, for shelter; half under ground, the half above being covered with stubble: at length, they planted trunks of trees an-end, laying others across, to sustain the covering.

Hence they took the hint of more regular Architecture; for the trunks of trees, upright, suggested columns: and the cross beams gave the hint of entablatures; as the coverings ending in points did of pediments. This is *Vitruvius's* hypothesis.

At length the *Greeks* regulated the height of their columns in reference to the proportions of the human body; by the *Doric* representing a strong, robust man; by the *Ionic*, a delicate woman; by the *Corinthian* a slender girl.

To give a general Idea of the Orders; we observe, that each order is composed of two parts, at least, viz. the column and the entablature; or of three parts, if there be a pedestal under the column. The column has three parts, viz. the *Base*, the *Shaft*, and the *Capital*. The entablature also has three parts, viz. the *Architrave*, the *Frieze*, and the *Cornice*: which parts differ in their proportions in the several orders.

The TUSCAN ORDER is the most simple, and most solid: its column is seven diameters high; its capital, base, and entablature have few mouldings, or ornaments.

The DORIC ORDER is the second. The height of its column is eight diameters. Its frieze is divided and ornamented by Tryglyphs, and Metopes.

The IONIC ORDER is the third; and is more delicate than the former. The height of its column is nine diameters. Its capital is adorned with volutes, and its cornice with dentils.

The CORINTHIAN ORDER, invented by *Callimachus*, is the fourth, the richest, and most delicate. Its column is ten diameters high. Its capital is adorned with two rows of leaves, and eight volutes, which sustain the abacus. Its cornice has modillions.

The COMPOSITE ORDER, is so called, because its capital is composed from those of other Orders; having the two rows of leaves of the *Corinthian order*, and the volutes of the *Ionic order*. It is also called the *Roman*, because invented and used at *Rome*. Its column is ten diameters high; its cornice has dentils.

In Building there are three things chiefly to be studied: Convenience, Firmness, and Pleasure. To attain these, we may consider this subject under two heads, the *situation* and the *structure*.

For the *situation* of a building, regard should be had to the quality, temperature, and salubrity of the air; the conveniency of water, fuel, carriage, &c. and the beauty of the prospect.

For the distribution of the parts of a building, the observation is, the chief rooms, studies, libraries, &c. are to lie toward the east: offices that require heat, as kitchens, distillatories, brew-houses, &c. to the south: those that require a fresh cool air, as cellars, pantries, granaries, &c. to the north; as also Galleries for paintings, Museums, &c. which require a steady light. The ancient *Greeks* and *Romans* generally placed the front of their houses to the south; but the modern *Italians* vary from this rule.—Indeed in this matter, regard must be had to the general properties of a country, all places being obliged to provide against their respective inconveniencies; so that a good parlour in *Egypt* might make a good cellar in *England*.

The *structure* of a building, may be considered as composed of first, the *principal* parts; then the *accessories*, or ornaments. To the principals belong, the materials, and the form.

The *materials* of a building are either stone, marble, brick, or wood, as fir, oak, &c.

The *form* of a building, must either be *simple* or *mixed*.—The simple forms are either *circular* or *angular*: the mixed are compounded of both.

The circular form is commodious, of great capacity; strong, durable, and beautiful; but the most chargeable: loses much room when divided; and has an ill distribution of light, except from the center: the ancients therefore, used the circular form only in Temples and Amphitheatres, which needed no compartment. Oval forms have the same inconveniencies, without the same conveniencies; being of less capacity.

Sir HENRY WOTTON observes, that *building* neither loves many, nor few angles: the triangle, *e. gr.* is condemned, wanting capacity and firmness; as also, because incapable of being gracefully resolved into any other regular figure in the partitions, beside its own. Figures of five, six, seven, or more angles, are fitter for fortifications, than for civil buildings. There is, indeed, a celebrated *building* of *Vignola*, at *Caprasia*, in form of a Pentagon; but the Architect had prodigious difficulties in disposing the lights, and saving the vacuities. Rectangles are preferred, as being a just medium between extremes. Of these an oblong, provided the length does not exceed the breadth by above one third, is usually most esteemed.

Mixed figures, partly circular, partly angular, may be judged by the rules which regulate the simple ones; but they offend against uniformity, though they admit most variety; and however uniformity and variety may seem to be contrary to each other; yet they are both necessary to a happily composed building.

The parts of a building, have been comprised under five heads *viz.* the foundation, the walls, the apertures, the distribution and the coverings.

For the foundation, *Vitruvius* orders the ground to be dug up to examine its firmness; and its apparent solidity not to be trusted to, unless the whole mould cut through be found solid. The depth of the digging, *Palladio* limits to a sixth part of the height of the building, for structures of great magnitude, and weight.

This Sir *H. Wotton* calls the *natural foundation*, whereon are to stand the walls, which he calls the *artificial foundation*: this then is to be the level; its lowest ledge, or row, being of stone, close laid with mortar, and the broader the better; at least twice as broad as the wall. Some add, that the materials below should be laid just as they grow in the quarry, supposing them to have the greatest strength in their natural posture. *De Lorme* enforces this, by observing, that the breaking of a stone in this part of the fabric, though but the breadth of the back of a knife, will make a cleft of above half a foot in the superstructure.

The great laws of walling are, that all walls stand perpendicular to the ground-work; the right-angle being the cause of stability

stability: that the massiest and heaviest materials be lowest, as fitter to bear than to be borne: that the work diminish in thickness as it rises: that certain courses, of superior strength be occasionally inserted to sustain the fabric, if the under parts chance to decay: and lastly, that the angles be firmly bound, and united; these being the nerves of the whole, and commonly fortified, by the *Italians*, at the corners, even in brick buildings, with squared stones; which add both beauty and strength.

The APERTURES, are either doors, windows, staircases, chimnies, drains, &c. with regard to the last, art should imitate Nature in these ignoble conveyances, and seclude them from sight, with the utmost possible address.

In distribution there are two general views, *gracefulness* and *usefulness*: gracefulness consists in a double analogy or correspondence; first, between the parts and the whole; a large fabric should have large partitions, entrances, doors, columns, and, in general, all the members large. The second analogy is between the parts themselves, with regard to length, breadth, and height. The ancients determined the length of their rooms, that were oblongs, by double their breadth; their height by half their breadth and length, added together. When the room was square, they made the height half as much more as the breadth; these rules the moderns dispense with; sometimes squaring the breadth, and making the diagonal thereof the measure of the height; and sometimes more: according to circumstances, which require adaptation and management.

USEFULNESS, consists in having a sufficient number of rooms of each kind, with proper communications, and without interference. The chief difficulty lies in the lights and stair-cases. The ancients were pretty easy on these heads, having generally two cloistered open courts, one for the women's side, the other for the men's: thus the reception of light into the body of the building was easy; which, among us, must be supplied either by the open form of the building, or by graceful refuges or breaks, by sky-lights, &c. As to placing the offices, they should be neither so near as to be offensive, or intrusive on the company, nor so distant as that too much time should be consumed in passing to, or from them.

In the distribution of lodging-rooms, it is a popular fault among the *Italians*, to cast the partitions so, that when the doors are all open, a man may see through the whole house: grounded on the ambition of shewing a stranger all the furniture at once this is an intolerable hardship on all the chambers except the innermost, where none can arrive, but through all the rest.

In distribution, an Architect will have occasion for frequent shifts; through which his own sagacity, more than any rules, must conduct him. For instance, he will be frequently put to struggle with scarcity of ground; sometimes to ruin the appearance of one room for the benefit of the rest; in general, his aim should be to make those the most beautiful which are most in sight; and to leave the rest, as it were, in shadow, &c.

In the covering, or roof, two extremes are to be avoided, the making it too heavy, or too light: the first will press too much on the supports; the latter has no less inconvenience; for the cover is not only a defence, but, a band or ligature to the whole *building*; and requires a reasonable weight. Care should be taken, that the pressure be equal on each side; nor should the whole burden be laid on the outward walls, but the inner should likewise bear their share.—The *Italians* are curious in the proportion of the slope of the roof; dividing the whole breadth into nine parts, whereof two serve for the height of the highest ridge to the lowest: but in this, regard must be had to the climate, for those climates which fear the falling of snow, ought to have sharper roofs than others, that the snow may be of less quantity and weight.

The *accessories*, or *ornaments of buildings*, are derived from painting and sculpture. The chief rules to be regarded in embellishment with pictures are, that no room have too much, (this does not include galleries, or the like :) that the best pieces be placed in the most advantageous lights: rooms with several windows, are enemies to pictures, nor can any picture be seen in perfection, unless illumined like nature, with a single light. Also in their disposition, regard must be had to what side the light comes from, to their height from the eye, which is the most natural for the spectator; and their subjects must be accommodated to the intention of the room they are used in. Ornaments of sculpture, must not be too abundant; especially at the approach of a *building*, or at the entrance; where *Doric* ornaments are preferable to *Corinthian*; fine sculptures, should always have the advantage of nearness to the eye, and coarser performances of distance from it.

To judge of a *building*, Sir *H. Wotton* lays down the following rules.—That, before giving any judgement, a person be informed of its age; since, if apparent decays exceed the due proportion of time, it may be concluded, that the situation, the materials, or the workmanship, is bad. If it be found to bear its years well, let him advert, from the ornaments and things which strike the eye first, to the more essential members, having

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having determined on these, he may pronounce whether, or not, the work be commodious, firm, and delightful; the three conditions in a good *building*, first laid down and agreed on by all Authors.

In this judgement should be included the consideration, whether the walls stand upright, upon a clean footing and foundation; whether the *building* be of a beautiful stature; whether the principal entrance and others be well placed; as also the windows, offices, &c.

Vitruvius gives another method of judging: summing up the whole art under these six heads: *Ordination*, or settling the model and scale of the work; *disposition*, the just expression of the design thereof; *eurythmy*, the harmony between the length, breadth, and height of the several rooms, &c. *symmetry*, or the agreement between the parts and the whole; *decor*, the due relation between the *building* and the inhabitant: and *distribution*, the useful allotment of the several rooms for office, entertainment, or pleasure.—These last four are ever to be strictly attended to: and these are sufficient to condemn or acquit any *building* whatever.

Dr. *Fuller* gives us two or three good aphorisms in *building*; as,—1. Let not the common rooms be private, nor the private rooms be common.—2. A house had better be too little for a day, than too big for a year.—3. Country-houses must be substantives, able to stand of themselves: not like city *buildings*, supported and sheltered on each side by their neighbours. 4. Let not the front look askint on a stranger: but accost him right at his entrance.—5. Let the offices keep their due distance from the Mansion-house; those are too familiar, which are of the same pile with it.

The design of an edifice is commonly laid down on three several draughts.

First, a *Plan*, which exhibits the extent, divisions, and distribution of the ground, into the various apartments, and other conveniencies. Plans are often made for the several stories: as their distribution may differ occasionally.

A second drawing represents externally the stories, their heights, and the general appearance of the whole building: this is termed, an *Elevation*.

The third drawing is the *Section*, and shews the internal parts of the fabric; the front wall being supposed absent.

By means of the plan, the elevation and the section, an estimate may be made of the expence, time, &c. a building may require, according to its measurement. And the most accurate estimates

estimates are necessary in this art; because some things always occur that could not be foreseen; but for which in good estimates allowance is regularly made.

For it is to be regretted that there are some who being too great encouragers of *building*, ruin themselves, and the workmen they employ, by gratifying their desires beyond the limits of their fortunes. Hence we too frequently see, before the expiration of half a century, very stately and magnificent seats, which have cost immense sums, run to decay; or else by the money sunk in the erection of superb edifices, and the expence which attends their support with proportionate splendour, whole families are reduced to indigence.

The first is called *Pyrexia*, being one diameter and a half distant; the second is called *Diastole*, being two diameters distant; the third is called *Stasis*, being three diameters distant; and the fourth is called *Metastasis*, being four diameters distant. The distance between the first and second is called *Diastole*, the distance between the second and third is called *Stasis*, and the distance between the third and fourth is called *Metastasis*. The diameter of columns are always measured at the bottom of the shaft.

Plate II. Represents the different heights of the various orders, drawn to the same diameter, and shows how they differ in slenderness from the solid Column to the elegant Composite, as well the pedestal, as the shaft of the column, and the capital; these figures also show the peculiarities of ornaments, and provide richness of the orders.

Plate III. The Doric order, the names of the parts are marked on the plate, these should be strongly committed to memory; and also the peculiarities of each order, which are the things of the column, and the triglyphs in the frieze, are peculiar to the Doric order; and wherever you see these ornaments they mark this order.

Plate IV. The Ionic order, the names of the parts are marked on the plate; commit these also to memory. The volute or scroll at the capital, is peculiar to this order; and marks it. No. 2. shows a volute whose two faces are not alike. No. 3. shows a volute which being seen on an angle, both its faces are alike: the first is the ancient volute to this order; the latter is the invention of Palladio.

Plate V. The Corinthian order, the foliage of the capital distinguishes this order. It has in fact the most complete quantity of ornaments, and is more stately and appropriate than the others; in point of richness it is capable of receiving any quantity of ornaments, and is more stately and appropriate than the others.

REMARKS

REMARKS ON THE PLATES ACCOMPANYING THE

ARTICLE ARCHITECTURE.

Plate I. This plate contains *plans of columns*: the square line shews the plan of the bases; as the circular and shaded parts, shew the plans of the columns, standing on those bases. These plans shew also, the distances between the columns, how they are measured, and how varied to suit different appearances; closer, or more distant, &c.

The first is called *Pycnostyle* or *peopled*; the columns being only one diameter and a half distant.

The second is called *Systyle* being two diameters distant; the third is called *Diastyle* being three diameters distant; and the fourth the *Areostyle* is four diameters distant; column from column. The *Eustyle* is two diameters and a quarter distant: this appeared *Vitruvius* the most agreeable medium between *too close* and *too distant*. The diameters of columns are always measured at the bottom of the shaft.

Plate II. Represents the different *heights* of the various orders, drawn to the same *diameter*: and shews how they differ in slenderness, from the solid Tuscan to the elegant Composite: as well the pedestal, as the shaft of the column, and the entablature; these figures also shew the peculiarities of ornaments, and progressive richness of the orders.

Plate III. The *DORIC* order: the names of the parts are marked on the plate, these should be strongly committed to memory: and also the peculiarities of each order: observe, the *sharp* flutings of the column, and the *trygliphs* in the frieze, are *peculiar* to the *Doric* order: and whenever you see these ornaments they mark this order.

Plate IV. The *IONIC* order: the names of the parts are marked on the plate: commit these also to memory. The *volute*, or scroll at the capital, is *peculiar* to this order; and marks it. No. 2. shews a volute whose two faces are not alike. No. 3. shews a volute, which being seen on an angle both its faces are alike: the first is the ancient volute to this order; the latter is the invention of *Palladio*.

Plate V. The *CORINTHIAN* order: the foliage of the capital distinguishes this order. This is in fact the most complete of the orders; in point of richness it is capable of receiving any quantity of ornaments, and is more chaste, and appropriate than the composite order.

Plate

Plate VI. The COMPOSITE order—that is to say, the Ionic order engrafted on the Corinthian, by the addition of the Ionic volute on the corinthian capital, and the Ionic dentils in the entablature, &c. the characteric of this order, is richness and ornament, of which all its parts are susceptible.

Plate VII. Shews at large the BASES of the several orders; and by forming a comparison between them, shews also their progress in enrichment, &c.

Plate VIII. MOULDINGS such as are most frequently used; with their names annexed; whereby the student may learn to distinguish them, these names should be strongly committed to memory.

Plate IX. No. 1. Exhibits the Plan of a House—that is to say, the *geometrical* representation of the walls of the building supposed to be raised only so high as the level of the ground. It shews the door way or entrance, into the house—the passage—the place for the stairs—and the intended divisions of the house into rooms. It shews, also, that at the back front of the house is a circular window:—Now none of these particulars can be known from the other representations of the same edifice, No. 2. and 3.

No. 2. Is an elevation of the same building: shewing the situation and height of the door, of the windows, the stories into which the house is divided, the ornaments adapted, and, in short, the general effect of the front according to the design of the architect.

No. 3. Is a section of the same: that is to say, a *geometrical* view of the internal construction of the building:—so much as might be seen if the whole front wall of the house were taken away; it shews, the projecting part of the inside of the rooms; the chimney piece, the disposition of the doors, and occasionally of the furniture, or other ornaments: or of the timber works, and other principles of construction.

Upon reviewing these figures, it will appear that each shews somewhat which the other is unable to shew: but that from them all a very clear conception of the forms, proportions, and conveniencies, of a building may easily be obtained.

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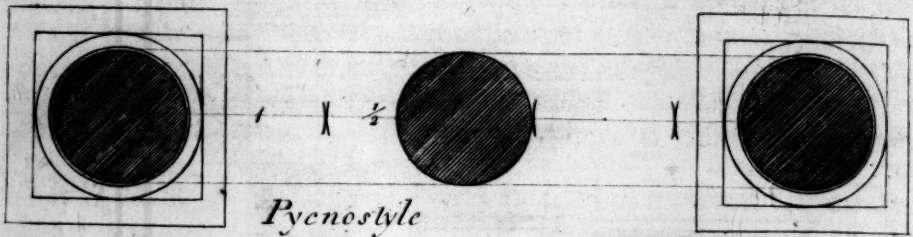
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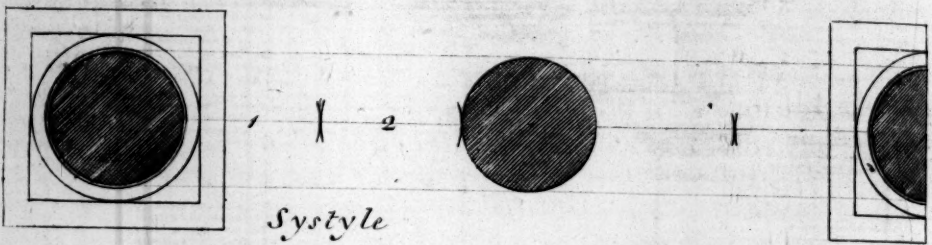
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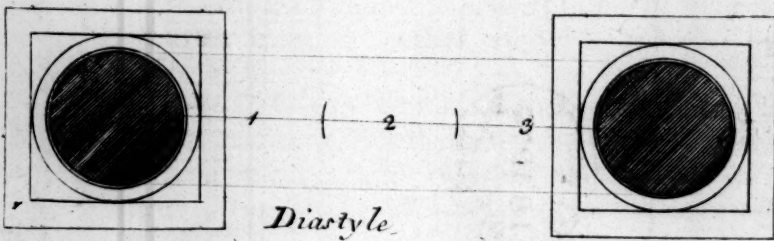
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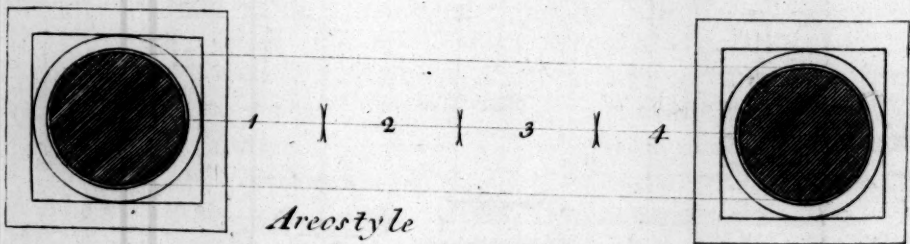
Pycnostyle



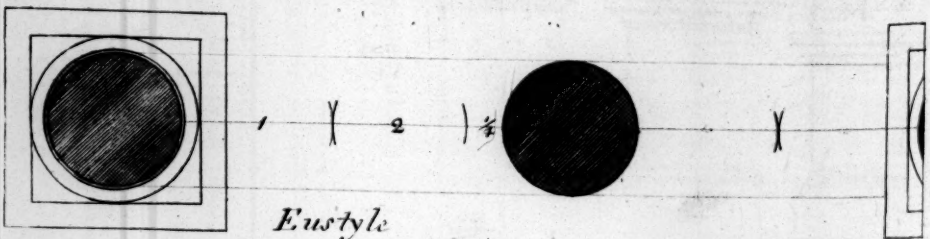
Systyle



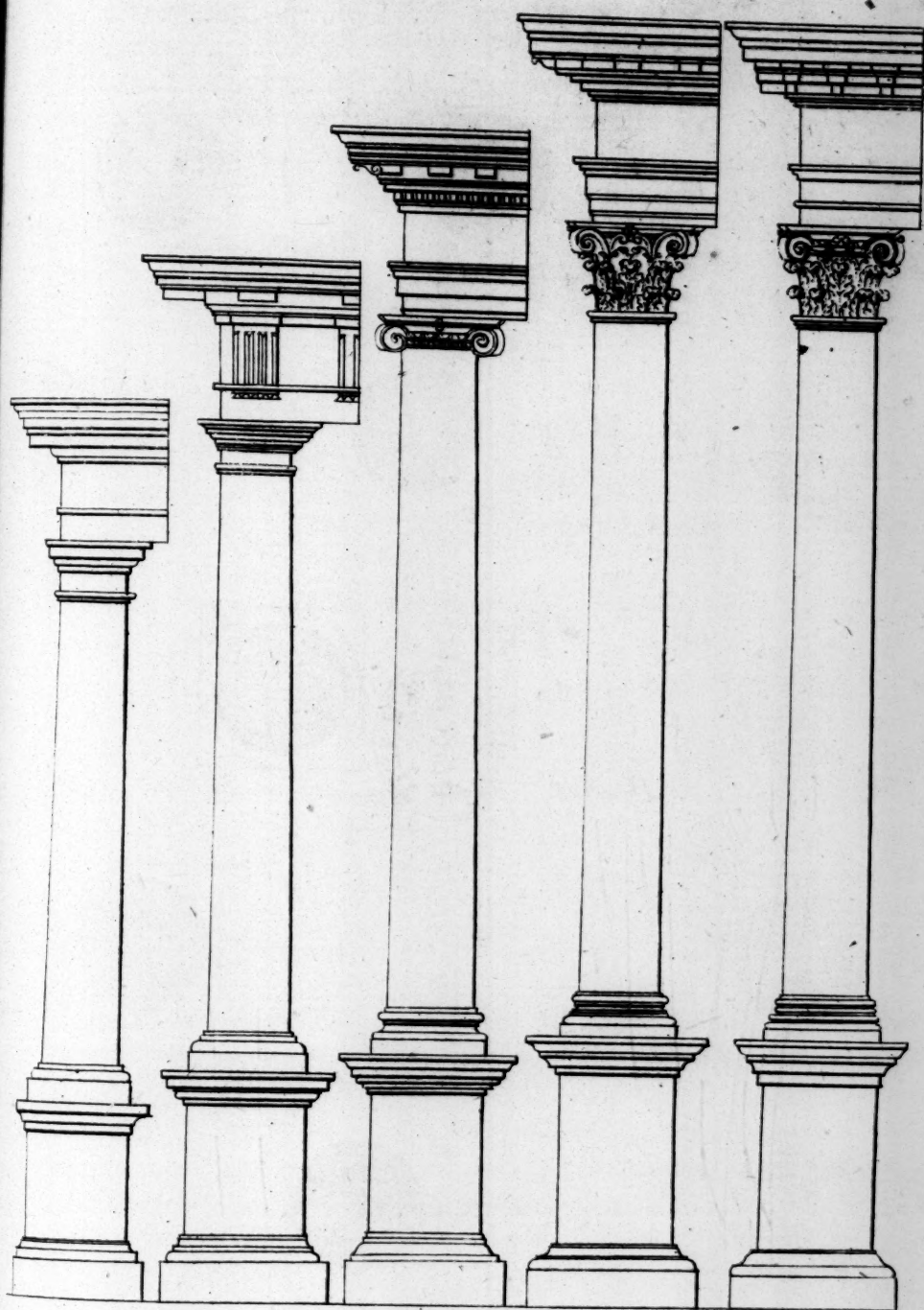
Diastyle



Areostyle



Eustyle

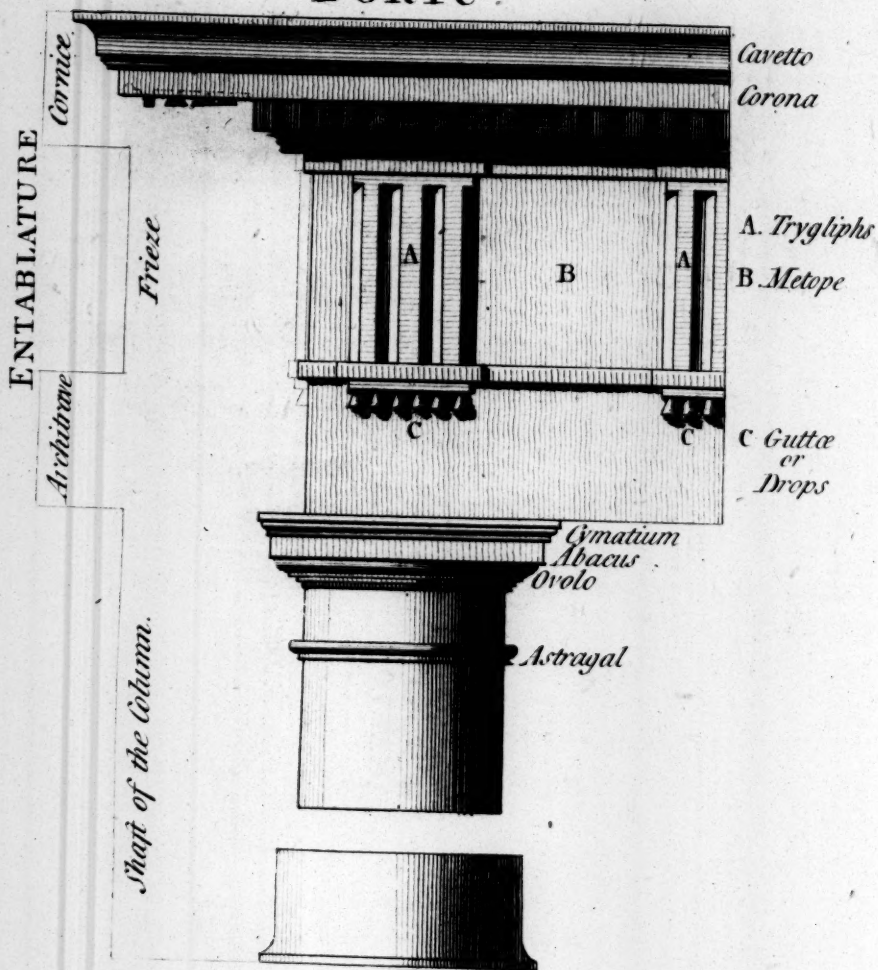


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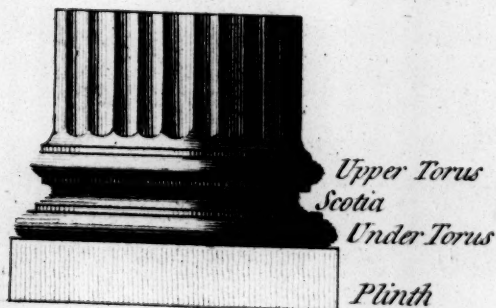




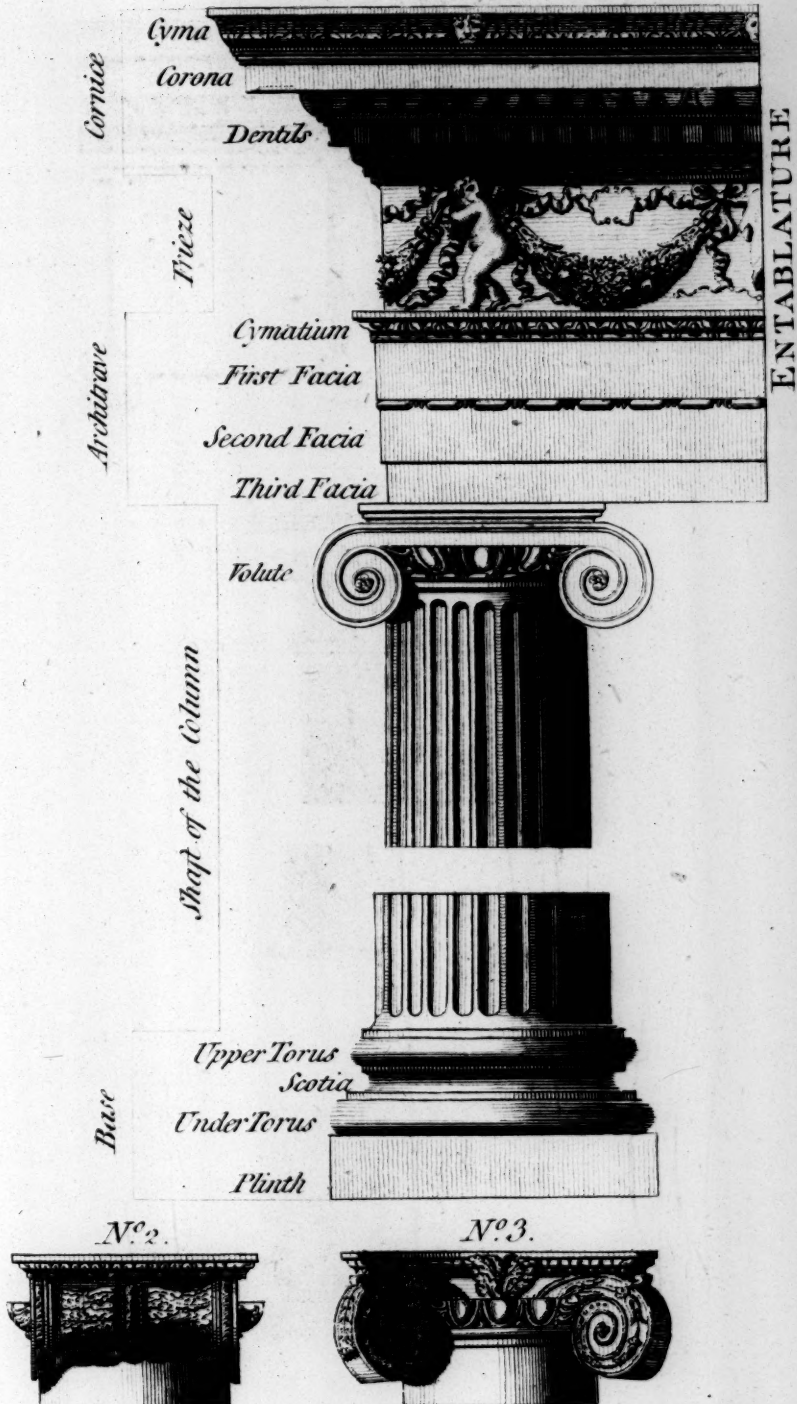
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No. 2.



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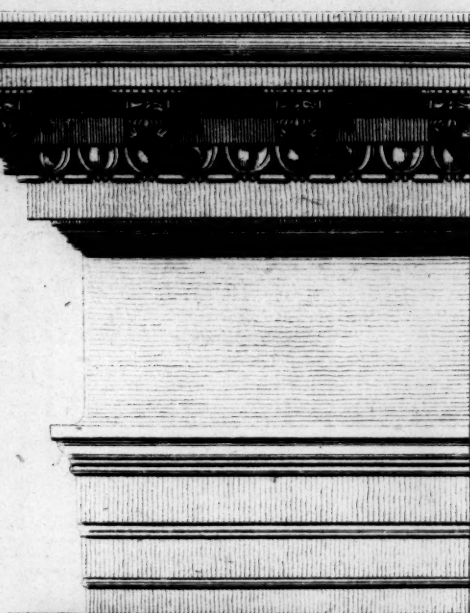




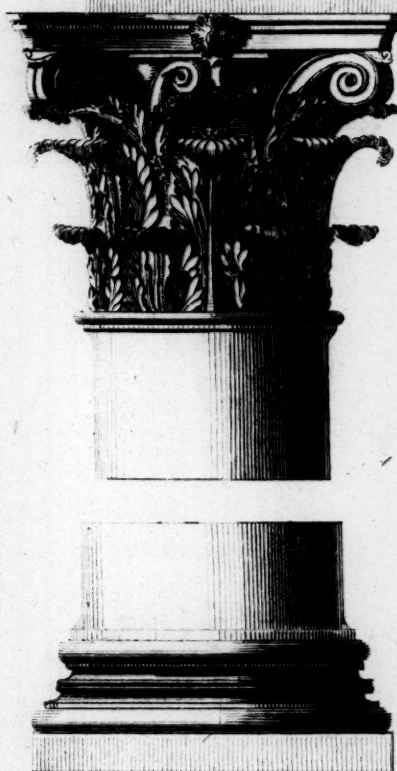


CORINTHIAN.

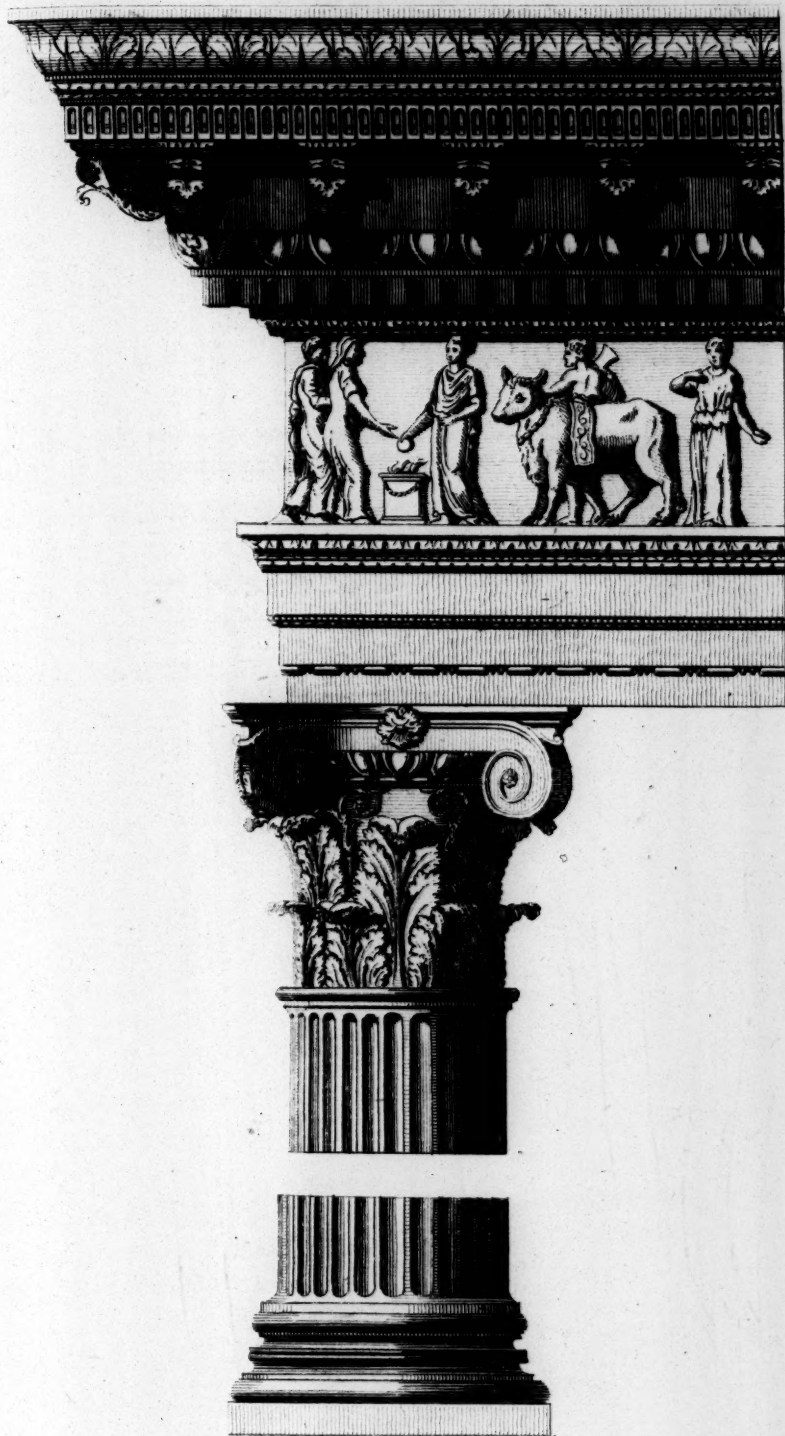
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Acanthos

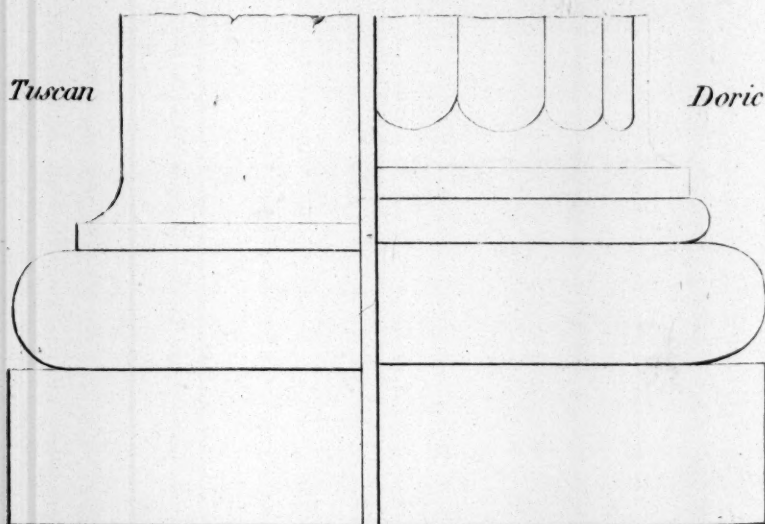
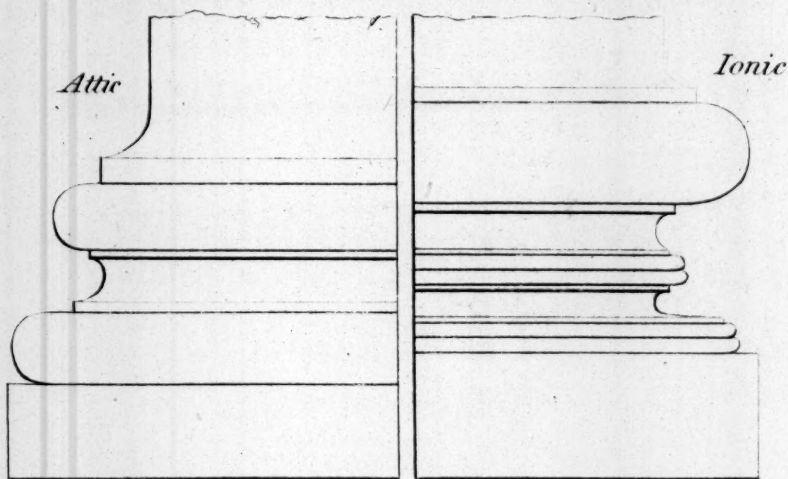
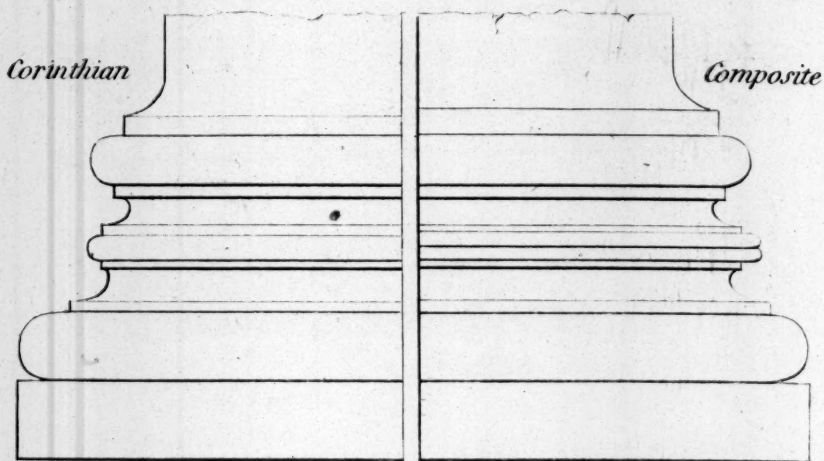


COMPOSITE.



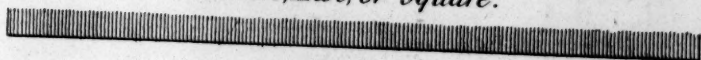




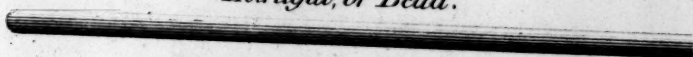


MOULDINGS.

Annulet, List, or Square.



Astragal, or Bead.



Cima reversa, or Ogee.



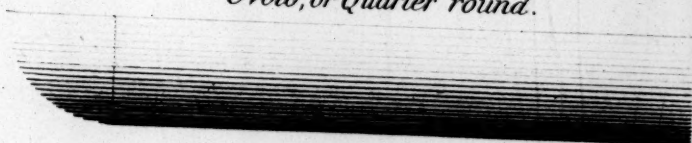
Cima recta.



Cavetto, or Hollow.



Ovolo, or Quarter round.



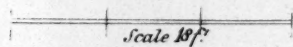
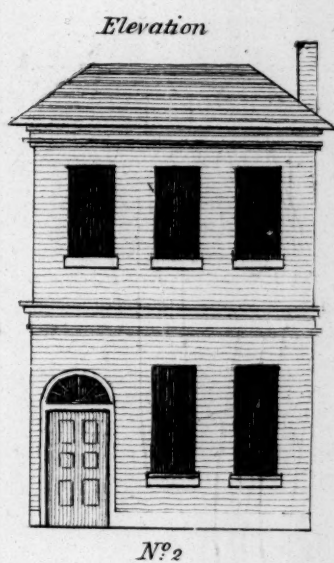
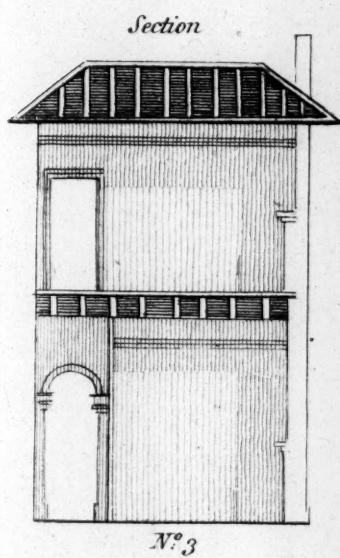
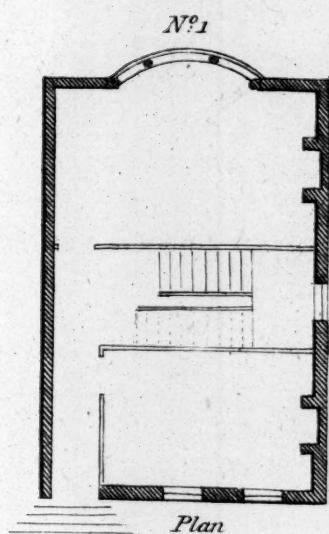
Scotia.



Torus.



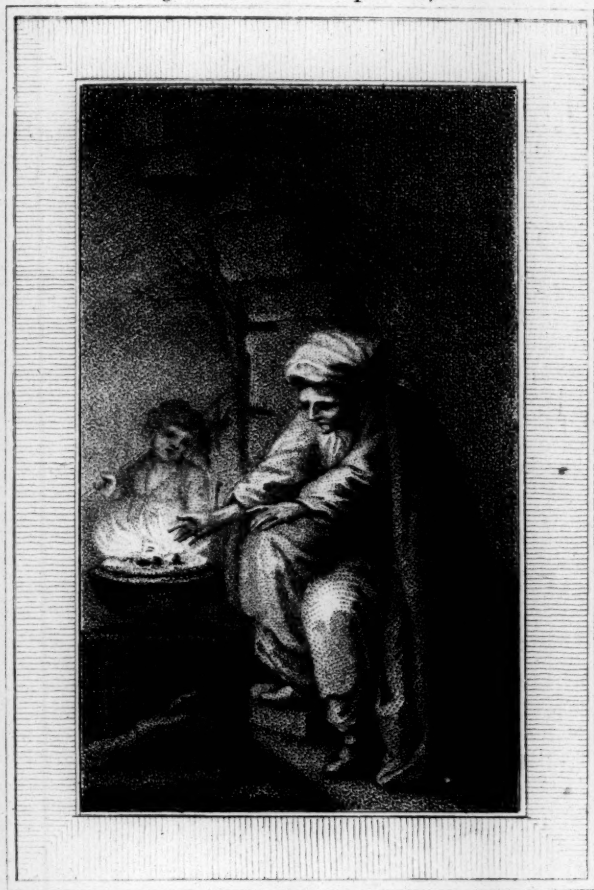






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H. J. H. H.

Fitzgeralds General Preceptor Vol. pa.



London, Published by C. Taylor, N^o 105, Hatton Garden, Sept: 1 1796.

WINTER.



Fitzgeralds General Preceptor Vol. pa:



London. Published by C. Taylor, N^o 105, Hatton Garden, Holborn.

AUTUMN.



Fitzgerald's General Preceptor. Vol. I. pa:



London. Published by C. Taylor. No. 5, Hatton Garden, Holborn. Dec. 1. 1796.

S U M M E R.



Fitzgeralds General Preceptor Vol. pa.



London. Published Oct. 1. 1796. by C. Taylor N^o. 105. Hatton Garden.

SPRING.





London. Publish'd Jan^y 1797 by C. Taylor N^o 105 Hatten Garden.

AIR.

GENERAL GENTEEL PRECEPTOR.

P A R T VI.

BEING INTRODUCTORY PRINCIPLES TO THE
PROPERTIES OF THE ELEMENTS..
OF THE ELEMENTA I R.
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WHEN we examine closely those articles, whose apparent simplicity has determined mankind to consider them as elements, we find them little understood, and much of their properties remaining in obscurity: they may seem simple, and uniform, but this rather arises from our inability to investigate their minuter subdivisions and branches, than from the actual elementary termination of their principles. Of this, our present subject, the AIR, is an instance; which, though it has usually heretofore been thought pure and uncompounded, yet is found to include many and considerable varieties; it possesses also many remarkable peculiarities, whose effects are among the most striking and amusing of those exhibited by natural philosophy.

It would have been thought formerly a whimsical, if not a stupid opinion, that the air is HEAVY, yet such is the fact; and a man might as well be pressed to death by a weight of air, as by a weight of iron: it is also COMPRESSIBLE into a smaller compass or space, than it naturally occupies; and, on the contrary, it is EXPANSIBLE into a larger compass or space than usual; from which principles proceed its different densities, at different heights above the surface of the earth. Air is a fluid, in some instances pretty much resembling water; but unlike it in others; for instance, it cannot be congealed, or rendered solid, by being brought towards solidity. To exhibit a lump of air is beyond

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yond our powers, and yet we know that air enters into the composition of all solid bodies, and perhaps, they owe their solidity to it. The oak is greatly indebted to air for its hardness; metals and stones are partly formed of air, and every substance of every nature includes this *element* as one ingredient.

The reasonings of mankind proceed always by comparison: earth and water are heavy; of this our senses inform us, and none ever carried either without acknowledging the fact: but having no occasion to carry air, the senses of mankind, are unable to detect its weight; nor indeed was that weight capable of detection, till by some contrivance, a vessel emptied of air might be made to shew a difference from its weight when full. This has been accomplished; and if we weigh a vessel filled with air, then extract the air from it, and weigh it after such extraction, by the difference of its weights we find, that a cubic foot of air weighs upwards of one ounce.

These premises inform us, that the earth is surrounded by a ponderous fluid, rising very high above us: at the bottom of this fluid (especially,) are seen myriads of creatures, whose existence depends on it, who are perpetually moving about in it, and who, though compressed by it on all sides, are so adapted to their situation, as to feel no inconvenience from their immersion. Not only so, but *relieve* them from this immersion, they will quickly complain of insupportable anguish, and only by restoring this indispensable fluid, can comfort and enjoyment be restored to the sufferers. Nor is this all, we said, "at the bottom of this fluid" is the station of these beings, and to this only they are adapted, for the air becoming thinner in proportion to its height, it becomes proportionably unfit for respiration, the functions of life are performed with difficulty, and every exertion produces pain, weakness, and lassitude: on the contrary, I doubt not, that could we penetrate sufficiently far below the superficies of our habitation, we should find equal pain and equal imbecility, from the too great density of that medium which *should* contribute to the support of life. We cannot breathe in a fluid so dense as water; but descending deep into the earth, the air is capable of much further compression and density than that of water.

It is indeed true, that we are happily so constructed, as not to be greatly affected by those variations of air to which we are usually exposed; yet if those, as is undeniable, have their influence upon us, we may easily conceive that by extreme variations we should be rendered restless if not miserable.

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The general WEIGHT of the air is proved, (1) by weighing it in a very nice balance; which is performed by placing in one scale a thin glass flask, whose capacity is known, exhausted of its air, under the air-pump; counterpoise this by grain weights,—then, admitting the air into the flask, it will gradually overweigh its counterpoise. (2) By exhausting the air from a glass goblet (which is easily done by burning a bit of paper in it,) then quickly turning its mouth downward on water, the water will rise, and fill the inverted glass; the reason of this is, because the weight of the air, on the surface of that part of the water not covered by the glass, presses the water beneath it, and forces it to pass wherever it may find admittance: *i. e.* under the glass.

There must however, it is evident, be some bounds to the weight of the air; for if we suppose such a glass heightened, and the water rising in it, there must be some point at which it will stop, at which the weight of the pressing air, will be counterpoised by the weight of the admitted water; and this is found to be at the height of thirty-two feet of water. In clear words, the weight of thirty-two feet of water counterpoises that of an equal column of the whole atmosphere; whose height we know to be considerable. This has been experimented by pipes purposely made to this length. The proportion of the weight of air to water being known, we quickly find its proportion to any denser fluid. Mercury being fourteen times heavier than water, a column of air will be able to sustain a column of mercury only one fourteenth part of the height of a column of water; that is, about 28 or 29 inches. On this principle barometers are constructed; and by this instrument we learn, that though the air be always heavy, yet its weight varies, being sometimes a little more, sometimes a little less. Long observation has determined that the column of mercury does not usually rise higher than 31 inches, nor fall lower than 28 inches, the medium is 29 inches and a half.

This rising or falling of the mercury, indicates a more or less vaporated state of the atmosphere; for vapours being lighter than air, rise and float in it, and by occupying more space than an equal quantity of air, they diminish the weight of the atmosphere about them, consequently a shorter column of mercury may counterpoise it: but when the air is free from vapours, its natural weight requires a higher column to equal its pressure.

If we ascend to any considerable height, as of a hill, or a mountain, we may be said to cut off a portion of the column of atmosphere, (and that the densest part of it,) equal to the height we ascend; we should expect, in course, a proportionate

part of the column of mercury to be cut off, and we actually find, that the mercury subsides nearly one-tenth part of an inch for every hundred feet of perpendicular height; hereby this instrument becomes a method of measuring the heights of mountains, &c. merely by indicating the proportionate weight of the air on their summits.

The most wonderful application of the air's weight, is in the engine for raising water from great depths, mines, &c. commonly called the fire-engine:—human strength fails and needs recruiting, but the business of this engine suffers no cessation; if we change human strength for that of animals, they also fail by continued labour: but the philosopher, by means of a little steam to procure a vacuum in a cylinder, a little cold water to condense the steam, and the weight of the air on the top of the cylinder, produces a perpetual effect. In some engines the weight of the air employed is five, six, or seven tons; and they give fifteen or sixteen strokes in a minute. How little was so capital an application of this principle foreseen by those Virtuosi, who at first amused themselves with considering the theory of the weight of the air.

The air covers the earth's surface, with a weight equal to that of thirty-two feet of water: what a vast weight! if the whole atmosphere be thus calculated! but, the weight of atmosphere sustained by ourselves, is far beyond what curiosity suggestion might suppose; for, as fluids press equally on all sides, every part of us is exposed to this pressure. To raise water thirty-two feet, requires a weight of fifteen pounds on every square inch; now if we ascertain the number of square inches in the surface of our bodies, this, multiplied by fifteen, will demonstrate, that *thirty thousand* pounds of pressure is exerted against us! But the state of the air varies as we observed; and this variation produces three thousand pounds pressure of air, more at some times, than at others. This great difference, must necessarily affect the animal functions of our nature, and consequently our health: asthmatic persons, for instance, want the powers of a clear, dense, elastic air: an air less elastic, is incapable of properly actuating their organs of respiration.

A clear air being best adapted to our natural organs, is the reason why we suppose the air to be lightest in fine weather, when it is really the heaviest.—Whereas the fact is, that then this air braces our nerves and fibres, and invigorating our whole system, renders us alert and lively; relieving us from the oppressive relaxation which accompanies a less favourable state of the air. We are in this view our own barometers, and can as
certainly

certainly tell every variation of the air around us, as the nicest instrument; though we cannot ascertain or adjust it by a scale of feelings.

It is natural to enquire, how we are enabled to support this pressure, not only to support, but to be insensible of it? We move without hindrance, we exert our strength, our limbs, and no impediment prevents our motions. The fact is, air possesses a spring exactly proportionate to its density and weight; thus its resistance being equal to its pressure, that pressure becomes null. The proof is easy: fill a bladder with air; it resists the air around it on all sides, with the utmost precision of resistance: place a weight upon it, it gives way; its spring is not equal to support that weight, not being adapted to it, or designed for it; extract a little of the air, its spring is diminished proportionably, the bladder sinks. This experiment needs no instrument; but under the air-pump, we shew the weight of this fluid by extracting the air from a thin square bottle,—the pressure of the outward air on all sides soon crushes the glass. The spring of the air we shew, by closing a similar bottle full of air, and exhausting the receiver around it, the air included in the bottle finding no resistance from without, escapes from confinement, by bursting the bottle to shivers. The resistance of air, then, is equal to its pressure;—and here we see the reason of its DENSITY being greater near the earth, than in its upper regions; because the lower strata of air support the weight of the upper; and have less room wherein to expand.

Though air penetrates every where, so that every thing may be considered as full of it, yet the quantity of air may be increased in a proper recipient. For instance, a hollow globe of air, is we say, full of air, but by means of a hollow neck united to it by a valve, a piston may be made to drive the air contained in the neck into the globe, till, by continued working, the globe shall contain twice as much air as before; and this may be continued till the globe (if strong enough) contains twenty or thirty times its original quantity of air. Thus far I myself have worked it; but to what degree air might suffer compression by farther strength is unknown; a nutshell might contain the atmosphere! The clearest proof I know of this, is the quantity of air which may be extracted from certain subjects: a cubic inch of nitre yields *five hundred times* its bulk of air: reckoning therefore its earth for nothing, the air it contained has suffered a wonderful compression, by a process of nature unknown to us. We cannot push this experiment to its extremity; human strength, or art, is limited, and solid air is beyond our production.

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We turn our attention to the reverse of this ; air is **EXPANSIBLE** beyond our conception. Heat is the general agent in this effect : whether the heat of the sun or of fire. The force of gunpowder arises from the air expanding by heat, and all the fatal effects attending this invention are produced by a little air inclosed in the nitre which forms part of the composition. Nay, the force of expanding air may be justly thought to shake the solid earth ; and it has been said, an inch of air *may* be expanded to an extent equal to that of the whole annual orbit of the globe.

Such are the general and obvious properties of air, those which we may any day demonstrate without trouble, it is heavy, compressible, and elastic ; this is further proved by that simple instrument the pop-gun, in which, the air suffers compression to a certain degree, but beyond that degree it manifests its spring by driving the pellet before it.

The personal services we receive from this fluid, are obvious and incessant, every breath we draw, we experience them ; it is a friend whose kind offices every moment support us ; exclude it we die. The weight of the air is thought to force our juices into circulation, which is also promoted by its elasticity. It is thought also to contain a spirit, which, invigorates our blood, by mingling with it. We cannot indeed determine *how* it acts, but that it really has very great effects on our vital powers, is evident. That portion of our blood which has just received the action of the air, differs greatly in colour from that which has performed the circulation, being of a fine florid scarlet colour, while that which returns from its course, is of a blackish crimson : the air produces this difference. Air was formerly thought to *cool* the blood, and certainly air carries off a somewhat from blood : but we now rather think that air *communicates heat* to the blood, and that this heat is the spirit which invigorates it.

Beside supporting animal life, air confers many other benefits ; without air flame will not exist, under an exhausted receiver a candle quickly expires ; gunpowder will not explode, ignited wood ceases to burn,—propagation and vegetation make no further progress ; neither will seeds grow, nor eggs produce young : and it is not too much to say, that without air the operations of nature would be checked, if not absolutely suspended.

A remarkable instance of the necessity of air, occurs in fish, which, though natives of another fluid, to which all their manners are adapted, yet are furnished with magazines of air ; from time to time they rise to the surface to recruit their stock, and if totally deprived of air, they die. Fish in ponds which are
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frozen over certainly die, but if the ice be broken to supply them with air, they remain unhurt by cold.

If creatures formed for the waters die without air, no wonder those destined to inhabit the atmosphere, cannot subsist when deprived of it; every branch of nature depends on this element. Plants, as we have said, will not vegetate in an exhausted receiver. "All plants have within them a quantity of air, which supports and agitates their juices. They continually imbibe fresh nutriment from the air, to supply the wants they sustain from evaporation. When, therefore, the external air is drawn from them, they are no longer able to subsist. Even that quantity of air which they before possessed, escapes through their pores into the exhausted receiver; and as this continues to be diminished, they become languid, grow flaccid and die. However, the plant or flower thus ceasing to vegetate, by being secured from the external air, is kept sweet a much longer time than it would have continued, had it been openly exposed.

"Air is still more necessary to the life of animals; there are none found, howsoever seemingly torpid, that do not require their needful supply. Many have been the animals that idle curiosity has tortured in the prison of a receiver, merely to observe the manner of their dying. We shall, from a thousand instances, produce that of the viper, as it is known to be one of the most vivacious reptiles in the world: and as we shall feel but little compassion for its tortures. Mr. Boyle took a newly-caught viper, and shutting it up into a small receiver, began to pump away the air. "At first upon the air's being drawn away, it began to swell; some time after he had done pumping, it began to gape, and open its jaws; being compelled to open its jaws, it once more resumed its former lankness; it then began to move up and down within, as if to seek for air, and after a while foamed a little, leaving the foam sticking to the inside of the glass; soon after the body and neck grew prodigiously tumid, and a blister appeared upon its back; an hour and a half after the receiver was exhausted, the distended viper moved and gave manifest signs of life; the jaws remained quite distended; as it were from beneath the epiglottis, came the black tongue, and reached beyond it; but the animal seemed by its posture, not to have any life: the mouth also was grown blackish within; and in this situation it continued for twenty-three hours. But upon the air's being re-admitted, the viper's mouth was presently closed, and soon after opened again; and for some time those motions continued, which argued the re-
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mains of life." Such is the fate of the most insignificant or minute reptile that can be thus included. Mites, fleas, and even the little eels that are found swimming in vinegar, die for want of air."

But, we have to remark, that all air is not alike: there exists (1.) air *purser* than that which composes the atmosphere; there exists also (2.) air *lighter* than that of the atmosphere; and (3.) another kind *heavier* than that of the atmosphere. There are other varieties; but we shall chiefly attend to these distinctions because they are simple, and easily retained in the memory.

That the atmosphere being the grand repository of vapours, steams, and exhalations, should become less pure than if it were free from such mixture, is very conceivable, and has long been supposed; but by what means to procure an air free from those impurities, was a *desideratum*. Accident furnished what search had missed. A purer kind of air, sometimes termed *dephlogisticated air*, is yielded by nitre in great abundance, by red-lead in great purity, and has been procured nine-hundred times purer than atmospheric air. Its properties and use, are very friendly to flame; a candle recently extinguished, flames again on being immersed in pure air: it burns also very much brighter in pure air; and light, in general, becomes more brilliant. But if a candle burn brighter, it burns much faster; and though pure air has its uses in medicine (as where the lungs are affected,) yet did we live always in this kind of air, our lives might be merry, but they must needs be short; vitality might be exhilarated, but it must be speedily consumed. Unable to improve this essential of life, we congratulate ourselves on a situation more happily adapted to necessities, by those very causes which *seem* so many impurities. Nay, let us reflect a little, we shall find nature taking some pains to promote impurities of certain kinds. The motions of the waters, the rising and falling of vapours, produce a degree of fermentation. A portion of putridity is essential to vegetation, probably, therefore, to all life; but, that this may not superabound, nature employs means for diminishing it. Plants absorb, and, as it were, feed on putrid matter arising from stagnant waters, and they breathe out purer air; but they will not thrive (if they will live) in quite pure air. Besides, when a mixture of impurities predominates, storms and tempests are violent methods, as showers, dews, &c. are gentle methods of precipitating them. In fact, it is rather when any one kind of impurity prevails in the air, that it becomes unwholesome, than when several kinds counterbalance each other. Hence among other causes,

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the benefits of change of air; since, by leaving that air in whose mixture we have long dwelt, we procure a variety whose composition is not totally different (that would shock us,) but in which some different principle prevails, whose diversity improves the fluid by which we are sustained, or counteracts those to which we have been used.

We have described another kind of air, as by very much LIGHTER than atmospheric air; this is procured from steel filings, to which is added water, and spirits of vitriol, to corrode the steel. Many other materials yield this kind of air, which is thirteen times lighter than atmospheric air. It was with this kind of air, balloons were filled; and its lightness buoyed up those machines till they rose to a region where the air was equally light with themselves. This kind of air is inflammable, and is usually termed inflammable air, and it is curious enough to see a tube from the bottle containing the ingredients, lighted at a candle, and continue burning, so long as the mixture furnishes the air; or if a quantity of this air be received into a proper bottle, it will explode like a pistol. I have heard a very loud report from it, when the quantity has been considerable; and it will drive out a cork slightly put into the mouth of the bottle, like a ball from a pistol. This air is fatal to life, and often occupies the upper parts of pits, caverns, mines, &c. where being unventilated it does much mischief; especially if by accident it catches fire.

A contrary kind of air is that which is HEAVIER than atmospheric air, as 3 to 2; this descends to the bottom of pits, caverns, mines, &c. where it is equally fatal to life, and extinguishes flame.—This ⁴⁴⁰abounds in all bodies, is esteemed a bond of their union, and is denominated *fixed air*, or *aërial Acid*, or *Mephitic Gas*. It is procured from lime-stone, potash, &c. The largest portion of it is procured from fermenting vegetables, and is what offends us during the progress of their putrefaction;—wines, beers, and liquors of all kinds, receive their pungency, their spirit from it; for if they be deprived of this air, they become flat, and insipid. Sugar, put into vinous fermentation, has been found to contain 57 parts out of 100 of fixed air. The *Grotto del cane*, near Naples, produces this noxious vapour remarkably; it rises in abundance, to the height of about fourteen inches above the ground. Many thousands of dogs have been killed by immersion in the steam; but the cruel experiment is not now often repeated, and perhaps may cease, when this vapour is discovered to be an article with which we are familiar. I shall just remark, that on putting the dog's nose
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within reach of the vapour, he quickly becomes senseless, and if continued in it, he dies; but if withdrawn in time, he gradually recovers, after being stretched on the grass. How happy is it for mankind that this vapour does not usually abound in sufficient quantities to produce the mischiefs of which it is capable! Though it destroys life, this acid gas stops putrefaction;—ice will not imbibe it, but water in freezing resigns all it contained. Though we too frequently hear of lives lost by descent into beer-vats, &c. where this vapour resides. Yet this kind of air has its uses in medicine, and is conveyed to the stomach with proper correctors: it has salutary effects in the sea-scurvy, which is thought to be occasioned by the seamen's food consisting of provisions from whence it is expelled. This kind of air then fatal as it is, is as necessary to life and to health as any other, and corrected by others, is salubrious and indispensable. The same remark applies to all kinds of air:—their mischief is not altogether in kind, but in superabundance and disproportion.

To what a series of seeming contradictions have we now been attending! Air is necessary and indispensable to life; it is also destructive as poison! Here it contributes to juncundity, there it overpowers with torpor; here it rises and floats, there it sinks and descends; here it is too light, there it is too heavy; here it supports flame, there it extinguishes it; here it is too pure, there it is putrid; and yet all this is necessary! by union, and commixture, by action, and re-action, the whole atmosphere is tempered, and fitted for its offices. What a providential combination of principles concur to produce the air we breathe! By the little we discern we may conceive of that infinite skill which regulates all nature: for we see but little of nature's secrets, we trace but a few of nature's operations; could we inspect those more extensive and important, we should think less of our present knowledge. Yet we must be sensible, that enough which concerns our well-being is opened to our inspection: all that contributes to life, is not necessary for us to know in order to our lives; and when, after much research, we hit on a discovery, it rather furnishes a subject of admiration, than a necessary natural enjoyment; for were it otherwise, and that those only who knew the secrets of nature, were capable of natural enjoyment, the wisest might lament that ignorance which admitted so little satisfaction. But Providence has distributed its gifts to all, that all might render their tribute of gratitude. While we readily own that whoever has attained superior knowledge, whether of the causes of things, or of their combinations, whether of their diversified



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diversified utility, or their many-operative powers, such an one has much to inform his mind, to entertain his reflection, to amuse his imagination, to invigorate his understanding. Such an one may congratulate himself on the advantages of his station, and while without reluctance he considers all mankind as common sharers in general benefits, let him highly value those attainments which contribute to his individual satisfaction and to his personal felicity.

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OF THE ELEMENT WATER.

AFTER air we place Water; a fluid, whose abundance and universality, has exposed it to the strictest trials and experiments of the most accurate philosophers; yet have philosophers little to boast of respecting their knowledge of its nature or composition, beyond the veriest rustic who without enquiry flakes his thirst in the stream. What we know of it, resolves into a confession of its powers, its usefulness, and its general distribution throughout nature. It is true, this latter idea (its general distribution) escapes the observation of our senses, and eludes the remarks of curiosity itself, which startles at the suggestion, that the most solid bodies are very greatly compositions of water! and yet this is fact. Water is (next perhaps to fire) the most fluid body in nature, it penetrates where air is unable, and oozes—not through chinks, but through pores too small for the passage of any other fluid. A variety of experiments places this beyond a doubt: and for a vessel impervious to water, we need entertain no apprehension of its transmitting other liquors. We own, indeed, that water is not always so sudden in bursting from confinement as air, which rushes out vehemently at once, if opportunity be offered, or as quicksilver, which, because of its weight takes instant advantage of the smallest crevice; but though less hasty, it is more certain, and in the end accomplishes its purpose where those fluids fail. Air will not pass through leather, but water will; a fact useful to the Negroes of Africa, who cool their water by hanging leathern bottles of it in the open air; the water pervading the pores of these bags, by its evaporation cools them and their contents, which produces a pleasanter and

more refrigerating beverage to the parched inhabitants of the torrid zone. Water will also escape through a bladder, where air will not; and the famous Florentine experiment informs us, that even the pores of gold are not sufficiently minute to refuse this element passage.---To ascertain this, a hollow ball of gold was filled with water, and firmly closed, then pressed with great force by huge screws, till the imprisoned element permeated its confinement, and stood on the surface of the globe in the form of dew.

If water be thus capable of passing the most solid bodies, and, by the fineness of its parts, of pervading their most minute recesses, it becomes evident there is no impossibility attending the conception, that it may also form a part of their composition. This is demonstrable with little labour; for whether we submit to the operation of the chemical furnace, vegetables, in which this principle abounds, or parts of animals, (such as dry bones,) or fossils, all yield water: and this is often separated from its subject by a gentle heat. By a little further advance, the hardest stones, metals, salts, and sulphurs, yield water plentifully. It is true, the fire seems unable to treat all subjects with equal success, but under the focus of a burning glass, the very diamond confesses its composition, and evaporates. Reflect a little, if you please, upon this; the diamond, whose firmness and union resists the hammer, which can be polished only by its own powder, that intractable gem whose hardness is proverbial, whose splendour and durability distinguishes it in the eyes of mankind; that gem which adorns the fair, and enriches crowns, is—merely a drop of solid water. Bring it to the test, it nearly vanishes in vapour. After this, we may easily admit the opinion of Newton, that “all birds, beasts, and fishes, insects, trees and vegetables, with their parts, grow from water, and by putrefaction return to it again.” It seems indeed to be that powerful and indispensable bond of union, deprived of which, bodies become mere shapeless masses of dust and ashes.

The idea of water being a principal component of all bodies is not new. Thales thought the same, the sentiment is understood to be countenanced by Moses himself. As, however, the truth rather than the antiquity of a sentiment, intitles it to reception, we rely on modern experiments in proof of this fact. Van Helmont made an experiment, by divesting a quantity of earth of all its oils and salts, then putting this earth, so prepared, into a garden-pot, which nothing but rain water could enter, and planting a willow therein; this vegetable, so planted, grew to a considerable height and bulk, merely from accidental asperfi-

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ons of rain-water ; while the earth in which it was planted received no sensible diminution. From this experiment he concluded, that water was the only nourishment of the vegetable tribes ; and that as vegetables are the nourishment of animals, all organized substances, owed their support and being to water alone. But Woodward rectified this mistake : shewing that water being impregnated with earthy particles, is the conveyor of substances into the pores of vegetables, rather than an increaser of them, by its own bulk : and likewise, that water is found to afford so much less nourishment in proportion as it is purified by distillation. A plant in distilled water will not grow so fast as in water not distilled : and if the water be distilled three or four times, the plant will scarce grow at all, or receive any nourishment from it. So that water, as such, does not seem to be the proper nourishment of vegetables, but only the vehicle which contains the nutritious particles, and circulates them through the plant. Pure water, may extend or twell the parts of a plant, but affords vegetable matter only in a moderate proportion.

To what degree water may be purified by distillation is doubtful, some affirming that after many repetitions of that process, it will deposit a sediment, while others think it may be freed from every extraneous substance. No method has yet been discovered, which may warrant our asserting that we possess water entirely pure ; and probably, when such a discovery shall be made, more sorts of water than one may be found. It is certain that as various airs become fit for the support of animals by commixture and without such mixture air would be useless or noxious ; so water, in the state nature offers it, is best fitted for those who are to use it. We have seen that vegetables suffer by too great purity of water ; and the same effects in a considerable degree, might be expected, should we drink distilled water only.

The wholesomeness of water, must be determined by experience since inhabitants of different places find that to which they have been accustomed (and which sometimes looks far from inviting to a stranger), both agreeable and salubrious.

A common test for water, is by trying whether it will form a lather with soap, or whether it will curdle, and this is thought to establish a distinction between hard water, as it is termed, and soft water. But hard water becomes like soft water by exposure to the air. Those waters are in general lightest which have fewest dissolutions floating in them, but no water can be obtained without some, according to the strata through which it has passed : and I well remember, having procured specimens of water from Springs in different parts of London, all of them extremely clear,

clear, yet each of them precipitated a sediment on the addition of a very small portion of acid of sugar. This is the origin of all mineral and medical baths, whose waters, in their passage through beds of metals, of sulphur, of arsenic, &c. dissolve and imbibe a part of the mineral through which they run. That natural springs therefore possess qualities which art cannot give to water, is not wonderful, when we consider the unknown and un-supposable combinations of minerals in any one bed; to which we may add, that by passing through successive beds of different sorts, a somewhat may be lost by the water, and a different somewhat gained. But of late, the qualities of the most celebrated waters have been closely imitated, and by the addition of various kinds of air (principally), the same taste, colour, and (some say) effects, are produced: nay it is not uncommon to make medical waters stronger of their ingredient principles, than the waters of the natural springs which are imitated.

Transparency is a very agreeable quality in water, yet is no determinate proof of salubrity, since sea-water is as transparent as any. River water is thought, upon the whole, the lightest; but we know, that Rivers receive many pollutions from various quarters; especially if their courses be through low and marshy lands; or if the course of any of those smaller streams, by which they are enlarged, be through such a channel. A river becomes in its progress more polluted than higher up the country, because it receives a stronger tincture from the quantity of plants, of minerals, of insects, of animals, &c. which the increase of its water is not sufficient to correct; and those who live at the mouths of great rivers, and drink their waters, are said to be unhappy proofs of this, and subject to many diseases in consequence.

The water of the river Thames is considered as superior to all other for keeping at sea; this has many impurities in it; but what I have heard asserted, seems, I think strange, that water taken up below London-Bridge, with all the pollution of the city in it, is preferable to, and keeps better than water taken up above the Bridge. Shall we say that this pollution subsides to the bottom, and carries with it much that is worse? or that it contributes to kill those insects which abound in all water? We know that all water by long keeping putrifies, and this, most probably, by reason of those minute insects, or vegetable seeds, which it contains.

But we must not suppose that the element itself, grows putrid, but the substances which it has imbibed, and which the utmost precautions by boiling, &c. cannot entirely destroy; for some survive the operation, and others find their way during the

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the time of its stowage. Seamen, assure us, that their water is generally found to putrefy twice, and occasionally three times, in a long voyage. In about a month after it has been at sea, when the bung is taken out of a cask, it sends up a noisome and dangerous vapour, which is combustible on the application of a candle. At this time the whole body of water is replete with little worm-like insects, that float very brisk, throughout it, for about a couple of days, these dying, their spoils for a while increase the putrefaction: but after a time, the heavier parts fall to the bottom, and the lighter float, in a scum on the top; this is what mariners call, the water's purging itself. To these however, succeeds another race of insects, bred, very probably, from the spoils of the former; which produce, after some time, similar appearances: but these die also, and the water is thought to suffer no more change. Nevertheless it very often happens, in hot climates, that nothing can clear the ship's water from these nauseous insects. They often increase to a very disagreeable and frightful size, so as to deter the mariner, though parching with thirst, from tasting that cup which they have contaminated.

RAIN-WATER is a fluid of Nature's own distillation, it is more friendly and nutritive to plants than any other; but where rain-water only is used by mankind, it is not the most salubrious, though, perhaps, its insalubrity is in great measure attributable to the reservoirs wherein it is kept, and to over-long keeping.

SNOW-WATER is drank chiefly, if not altogether, at the feet of the Alps, and other mountains; in Greenland, and in some parts of England: to the drinking of this water has been attributed those very large, I might say frightful, wens, or swellings, which disfigure the throats, &c. of the inhabitants in some places. But this opinion seems erroneous; as they are totally unknown in Greenland, which is covered with snow, and are common in Sumatra, where snow is a phenomenon which never occurs.

SEA-WATER is distinguished by its saltness; and this property of sea-water has long excited the opinions of the learned, and of course has long divided them. Some think, that rivers imbibing somewhat of saltness from bodies over which they flow, or which they carry to the sea, might in time, by leaving salts in the sea, render it salt: while others maintain, that the sea was formerly saltier than at present, the influx of fresh water gradually affecting the ocean: a contradictory mode of reasoning from the former, but equally void of demonstration or plausibility

plausibility. A third party hints at rocks of salt, fitly disposed to be dissolved by the waters (and such we know there are;) while those who think the water was originally created salt, urge much in support of that sentiment. Probably its degree of saltiness was never very different from what we now find it, for it seems, that though certain kinds of fishes are adapted to fresh water, yet their numbers bear little proportion to those which constantly inhabit salt-water, and cannot exist out of it. Now, if these fishes possessed at first the same natures as they do at present, their element was of necessity salt: this question seems therefore decided, without enquiring how far the saltiness of the sea is appointed to prevent its putrefaction;—for in small quantities at least, sea-water, the most strongly salted, will putrefy; and those who have been long becalmed in sultry regions, have witnessed a similar disposition in the ocean itself. Nevertheless this is no putrid disposition in the water, but in that immense quantity of animal particles, which in so many ages have replenished the ocean. As to the degree of SALTNESS in the sea, it varies in the same places at different seasons; sometimes at different depths; but in general it is found saltest where the sun is vertical, and where the water suffers the severest heat.

It appears from experiments, made in a voyage from England to Bombay, that the weight of the sea-water was greatest, not precisely at the Equator, but where the sun was vertical, and consequently, as just hinted, where the heat was greatest. The greatest weight of a definite quantity of sea-water, observed in sailing from 28° north latitude, to the Cape of Good-Hope, which is about $34\frac{1}{2}^{\circ}$ south latitude, in the months of May, June, and July, was at St. Jago island, north latitude 28° . The weights of equal bulks of Thames water, of the sea water at Teneriff, and at St. Jago, were 659—673 $\frac{1}{2}$ —780 $\frac{1}{2}$ grains; or nearly thus,—Thames water 1000,—Teneriff sea-water 1022,—St. Jago sea-water 1184. By comparing these numbers with a table in the Philosophical Transactions, exhibiting the comparative weight of equal bulks of simple water, and of water impregnated with different portions of sea-salt, it may be conjectured, that the Teneriff sea-water contained about $\frac{1}{32}$ of salt, and the St. Jago water about $\frac{1}{4}$ of its weight of salt, so that it was nearly, if not fully, saturated.

But, this very great proportion of salt in the water at St. Jago, seems liable to objection; since one-fourth of its weight of salt is full as much as is yielded by the best brine-pits in England, whose waters, filtering through rocks of salt, may be supposed to be fully saturated: and it is impossible to determine, whether
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such a cause might not be near, or have some influence on, the water examined as above. In general, sea-water possesses about $\frac{1}{25}$ to $\frac{1}{20}$ its weight of salt. And this proportion renders it by much more compact, more dense, and of stronger resistance than fresh-water, insomuch, that I have been told of deeply laden vessels, which having passed the dangers of the sea, too heavy to float on a thinner fluid, have sunk in port.

It is questioned whether water be COMPRESSIBLE: some think they have compressed it, so that a body of water occupied less space than before; but it should seem that water suffers but little compression, if any, and that if no deceptive appearances misled those gentlemen who maintain the affirmative, yet, that very small indeed is the effect produced by considerable strength: But when we mention its ELASTICITY and EXPANSION, neither calculation, nor imagination, can determine its limits.

Water expands by heat; and, what is very extraordinary, it also expands by cold: no machine can be invented, no strength can be applied effectually to confine water while freezing. We often notice bottles and vials, full of water and closely corked, if exposed to severe cold, cracked and bursten: were they made of iron, and an inch in thickness, they would experience the same; nay freezing water has been known to burst a cannon. If we seek further proof of its power, we find it in those huge fragments of massy rocks, which from time to time are separated from their parent mountains, and tumbled from their summits: think of their weight, their solidity, their size, then think of the cause which displaces them,—a little water, which having trickled through their fissures, till united in some hollow, is there frozen, and being frozen is dilated, and being dilated, expands from its confinement, and, if it cannot otherwise procure room, it will rend the very rock.

On this subject it is more usual to notice the very great expansive power of water, when converted into steam by fire: and since this affords a variety of useful machines, it may demand a little attention. We said lately, that the weight of air used in working some of the fire engines was six or seven tons; this weight is raised sixteen times in a minute with ease, by a quantity of steam introduced underneath it. This steam is not such as *might be*, but little if at all different, from that of a boiling tea-kettle. Yet one cubic inch of water is expanded into 2900 inches of this steam. Now the elasticity of steam increasing with heat, and the space it endeavours to occupy being proportionate to its elasticity; were it submitted to yet greater heat, it might become so much more expansive, as to occupy 15,000 or

20,000 times its former space. And this is rather a low estimation. The force of steam is taken at three times the force of gunpowder. So far has skill employed this element, and so far we may depend on its powers. Advancing on these ideas, there have not been wanting endeavours to account for the causes of earthquakes, by considering them as water rarefied into steam by subterraneous fires, and forcing a passage, not impeded (effectually) by the solid earth itself.

Water possesses, in common with all fluids, the property of *rising always to its level*; so that be the length of a pipe what it may, the fluid contained in it will stand equally high at both ends. This is well known to those who lay pipes over the sides of hills, &c. for if they can but form a reservoir at a sufficient height, the business is done. On this principle, the water distributed throughout London from the New-River, after descending into the town, would, of its own accord, mount into every cistern not higher than the eminence from whence it flowed. It is true, means are found to make it mount higher; but this is the effect of art. The same art appears in that useful machine the pump, wherein we see the water rise much above the level of the spring which furnishes it. This is merely the result of the weight of air, which being taken off beneath the pump, while the other parts of the water's surface are exposed to it, the fluid naturally rises where it meets with least resistance, and this, to such a height of water as counterbalances the pressure of the atmosphere, *i. e.* about thirty-two or thirty-three feet.

Water presses according to its *perpendicular* height: so that the same quantity of liquor which is one foot high, and three inches in diameter, if rendered only one inch in diameter, and consequently three feet high, acquires great increase of power by the alteration; and if reduced to half an inch in diameter, and six feet high, it would become yet more powerful. On this principle a pint of water may burst a hoghead; for if the hoghead be full, and the pipe through which the pint of water, attempted to be introduced, be of sufficient height, the weight of the water will make its way, and the vessel, unable to contain it, must yield to its pressure.

There is a very strange peculiarity of water, by which it rises in very small glass tubes without pressure, and of its own accord. If a glass tube have two curved legs (turning upward) one only a quarter of the diameter of the other, the water will always stand highest in the narrowest: if the disproportion be yet greater, the difference will be greater also. This phenomenon has puzzled the most sagacious observers; the attraction of the glass to the particles

particles of water, which is most predominant and effectual where there is the greatest quantity of glass and least of water, seems to bid fairest for solving the difficulty: but this is not entirely satisfactory.

Water assumes a form very different from any yet mentioned, and indeed incredible to those who have never beheld it; I mean that of ICE. I need not, in this climate, prove this fact: by art we produce ice in spite of the hottest summer, wherever we please. To account for ice is much more difficult: we know it is the effect of cold, but whether cold be a positive existence, in this case superadded to the water; or merely the absence of heat, in this case taken from the water, is doubted, and leads ultimately to the intricate question.—Whether water be a kind of metal held in fusion by a small degree of heat, or a natural fluid easily congealable? We have no other fluid (whose base is not confessedly aqueous) that freezes by any means so easily: but during the very severe depth of some late winters in Russia, mercury was discovered to be frozen; and the experiment has been repeated, by order, at Hudson's Bay. This, then, is an instance of a metallic body, solid in a due degree of cold, but rendered fluid by no greater heat than that of the general temperature of the air. This discovery is thought to be in some degree analogous: and to hint, that cold existed before heat, and that by heat all things (probably the very air included) were liberated from their bondage of inanity, and brought to that order in which we now enjoy them. I might further observe, that sea-water freezes equally with fresh, but requires somewhat stronger degrees of cold to produce ice: which ice is not salt, like its parent water, but fresh; the saline parts of the fluid remaining unfrozen. Salt-water ice thawed, and exposed a sufficient time to the air, makes good fresh-water.—[N. B. It deserves attention whether this water also becomes corrupt, and purges itself in keeping.] Water loses something in freezing, *i. e.* its fixed air; and something it seems to get, because it is increased in bulk,—but what we know not.

Water, gradually heated, gradually extends its bulk till it boils; but beyond boiling no art can force it. The phenomenon of boiling water is accounted for, by adverting to the admission of heat, and to the expansion as well of the water itself, as of the air included in it. That it rises no higher than it actually does, seems owing to the weight of the air which depresses it; for take off this weight under an air-pump, and we see water exhibit every appearance of boiling, at a degree of heat very much below what it requires in the open air. And indeed I

once found, by working an air-pump briskly, that it boiled strongly when its heat (to judge by the time it had been under the receiver) was very moderate.

The heat of boiling water is a fixed point beyond which no fire can force it: fiercer fire may accelerate its evaporation, but cannot augment its bulk, or its heat. The certainty of this point, which is the same all over the world, under the frozen coasts of Greenland, as under the torrid zone, renders it highly valuable; and the ease with which it may be procured, is a great advantage. Thus water affords us a determinate station in a scale of calculation, which human ingenuity has enlarged and extended to thousands of articles and circumstances.

Does not *this* subject also, justify the remark that "when we examine closely what mankind call *elements*, we find them little understood, and much remaining in obscurity?" and this idea strengthens, when we ask, What is the composition of water? It has been said to result from the union of two kinds of air, the pure and the inflammable. On attending an experiment made in support of this opinion; I observed the receiver was first clear and pellucid; as the inflammable air burned on the orifice of a tube introduced within it, the inside of the receiver became covered with drops like dew; these were enlarged, and they coalesced, till they ran down the sides of the glass; but whether by any means, atmospheric air might contribute water; whether the water was discharged from the ingredients which yielded the airs, and existed in, or combined with, those airs, and only became visible upon combustion, deserves consideration. From the general fineness and permeability of water, its intimate union with all bodies, and its notorious disguises, I think we must determine with caution. I have since heard, this experiment has been repeated with all possible precautions; a gigantic apparatus, a *sea* of mercury, and *electric* fire: the result was the same; the combustion produced water; nevertheless, my doubts are not wholly banished.

But whatever be the composition of water, its utility is beyond denial: as the original and natural beverage of mankind, it possesses unequalled advantages, since, by the fineness of its parts, it passes those minute channels which are impervious to other liquors; and since it has no disposition to inflammation. Nor ought it to be considered as a slight obligation we receive from this element, that it tends to health, and comfort, as it contributes to cleanliness; that it is cooling, and refreshing. In reality, the Turks seem not greatly mistaken, when they prescribe against the *hyp* "flourishing plantations, streams of water, and

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social beauty." For be it remembered, that without water, plantations would fade; few shrubs can endure the thirsty desert, and no trees; but wherever flows a stream, there vegetation thrives. We had a proof of these principles in St. James's Park, where many of the trees, being deprived of their usual refreshment, when, some time since, the canal was partly filled up, they withered and died.

The importance of this article being admitted, it is time to shew, that nature bestows it bountifully: almost every little hill, or rising-ground, in some places, has a spring; and we find water every where below the surface of the earth. In fact, the abundance of water is the greatest impediment to working mines of any considerable depth: it is frequent to meet with several streams, or branches of streams, or collections of springs, in extensive subterranean galleries; and this be the *depth* what it may; we have never yet *bored* the earth so deep, but we have had reason to think water-springs, perhaps rivers, were below us.

As to the natural causes of springs and Rivers, the theory of Dr. Halley seems at present to be generally received, and when we reflect, that in treating such comprehensive principles, we must, of necessity, reason from parts to a whole, and judge of what we do not see, by analogy with what we do see; we deny not that every hypothesis, may in some of its parts be liable to objections and yet, on the whole, it may be natural, just, and philosophical. Dr. Halley suggests, that the vapours exhaled from the sea, and driven by the winds upon land, are amply sufficient not only to supply plants with moisture, but to furnish the water of the greatest rivers. To determine this, the quantity of water emptied at the mouths of the greatest rivers has been estimated; as also has the quantity raised from the sea by evaporation; and it has been found, that the latter by far exceeds the former. It was judged, upon receiving such rain as fell in one year, in a vessel fitted for the purpose, that, one year with another, there might fall about twenty inches of water on the surface of the earth, throughout Europe. It was also computed, by M. Mariotte, that the river Seine, from its source to the city of Paris, might cover an extent of ground, that would supply it annually with above seven millions of cubic feet of this water, formed by evaporation. But, on computing the quantity which passed through the arches of one of its bridges in a year, it was found to be only two hundred and eighty millions of cubic feet, which is but the sixth part of the former quantity. Hence it appears, that this river may receive from the evaporated waters of the sea, a supply six times greater than what it returns to the sea by its current;

rent; evaporation therefore may be considered as more than sufficient for maintaining the greatest rivers; and supplying the purposes of vegetation.—In support of this theory, it is observed, that springs are rarely, if ever, on the summits of mountains, but on their sides, a little way down, thereby giving the waters room to collect; that the greatest rivers originate from the highest mountains, they attracting, stopping, and condensing the clouds, which, yielding to them their contents, furnish sources for the most copious streams; that where there are most clouds, are the highest mountains, the most rapid torrents, the greatest, and the longest rivers.

It seems further supported, by the peculiarity attending that immense ridge of mountains the Andes: on one side, they scarce know rain; a few clouds, now and then, are their distant visitants—here, rise gentle brooks, rills, and rivulets, which meander through the grove, and ornament the plain.—But on the other side the Andes, prodigious masses of clouds are perpetually forming, beating against the rocks, besieging, as it were this barrier, which forbids their passage, and tormenting, with storms, this boundary placed by Nature. What is the consequence? At many hundred miles from the sea, rise those floods which are rivers at their origin, and which receiving many like themselves, roll on, in one united deluge, to the ocean. While, therefore, this cause seems adequate to the purpose, we shall not incline to that theory, which supposes subterraneous waters furnished by the sea to be raised into steam, and converted into springs: since it most fails where most wanted, *i. e.* in accounting for the origin of the greatest rivers, which are always farthest from the sea, and always most highly elevated.

It is not uncommon, for rivers which rise near each other, to issue widely distant; the springs which furnish the Thames and the Severn, rise at no very great distance, though the mouths of those rivers, be at opposite parts of England.

With regard to the nature of rivers, we observe, that in whatever direction the ridge of the mountain runs which furnishes the stream, the stream itself takes an opposite course; never following the bearing of the land from whence it issues.

All rivers flow either from mountains, or elevated lakes, and in their descent, they acquire that velocity which maintains their future currents. At first the stream is generally rapid and headlong; but is retarded in its journey by continual friction against its banks, by the many obstacles it meets, and by the plains becoming more level as approaching the sea.

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If this acquired velocity be quite spent, and the plain through which the river passes be entirely level, it will, notwithstanding, continue to run, from the perpendicular pressure of the water, which is in exact proportion to the depth. This perpendicular pressure is nothing more than the weight of the upper waters pressing the lower out of their places, and, consequently, driving them forward, as they cannot recede against the stream. As this pressure is greatest in the deepest parts of the river, so we generally find the middle of a stream most rapid; both because it has the greatest motion communicated by the pressure, and because it has fewest obstructions from the banks on either side.

Rivers thus set into motion almost always make their own beds. Where they find the bed elevated, they wear it away, and deposit the sediment in the next hollow, so as in time to make the bottom of their channels even. On the other hand, the water is continually abrading and eating away the banks on each side; and this with more force, as the current happens to strike more directly against them: having always a tendency to render them more strait and parallel to its course. Thus it continues to rectify its banks, and enlarge its bed; but, the force of its stream diminishing till it has produced an equilibrium between the power of the water, and the resistance of its banks.

In plains and large vallies where great rivers flow, the bed of the river is usually lower than any part of the valley. But often, the *surface* of the water is higher than many of the grounds adjacent to the banks of the stream. If, after inundations, we inspect certain rivers, we shall find their banks appear above water, while all the adjacent valley is overflowed. This proceeds from the frequent deposition of mud, and such like substances, on the banks, by the rivers frequent overflowings; and thus, by degrees, they rise above the plain; and the water is often higher also.

Rivers are always broadest at their mouths; and narrower towards their source. They run more direct as they immediately leave their sources; and their sinuosities and turnings become more numerous as they proceed. It is esteemed a certain sign among the savages of North America, that they are near the sea, when they find the rivers winding, and frequently changing their direction: and this is become an indication to Europeans also, in their journies through those trackless forests. Now as those sinuosities increase. As the river approaches the sea, it is not to be wondered at, that rivers sometimes divide, and dischargeable

discharge themselves by different channels: as the Danube into the Euxine by seven mouths; the Nile, into the Mediterranean, by the same number; and the Wolga, into the Caspian, by seventy.

When the stream of a river is opposed by a jutting bank, by an island, by the arches of a bridge, or some such obstacle, this produces, not infrequently, a back current; and the stream having passed the arch with great velocity, pushes the water on each side of its current, toward the banks; not infrequently forming a whirlpool; in which a large body of waters revolves in a kind of cavity, lowest in the middle. The center of the whirlpool is lowest, because it has least motion: the other parts are supported, in some measure, by the violence of their revolutions; and, consequently, they rise higher as their motion is greater.

It might be supposed that bridges, dams, and other obstacles in the current of a river, would retard its velocity. But the difference they make is very inconsiderable. The water, by these stoppages, is forced to rise above the object; which, it having surmounted, it acquires a velocity that recompenses the former delay: Islands and turnings also retard the course of a stream but inconsiderably. Any cause which diminishes the quantity of water, most sensibly diminishes the force of the stream.

The rivers run to the ocean; to the ocean we now accompany them: it is among the sublimest objects of Nature. Solemn and grand, if calm, smooth, and serene, it plays its variously refracted tints of changing greens, and blues, and greys, as lights or shadows falls upon it, or if it be agitated by furious winds, and roll its buoyant eddies forward to the shore, roaring as they advance, hissing as they retire, seeming ready to overwhelm the very earth, yet yielding and changing their direction at every obstacle; it fills the mind with sensation! Human skill has availed itself of this element also; proud and licentious though it be, we plow the waters, and we navigate the ocean. It is, perhaps, the greatest of human triumphs! a striking demonstration of the superiority of reason, which chooses the best adapted means to accomplish its purposes, and even rules one ELEMENT by the assistance of another.

A few remarks on some prosperities of the ocean shall conclude the present discourse. We shall endeavour to explain the causes which influence the motions of the mighty waters, by considering (1.) the TIDES, (2.) the SURF, or SURGES of the ocean.

To render Tides observable, a very great body, or ocean of water, is necessary; there are several lakes, not unjustly denominated

nated seas, where the tide makes no sensible appearance; as the Caspian Sea, which though it receives one large river (the Wolga), and many smaller, yet is said to maintain always the same level of its waters; that is (for the mystery is very solvable) the quantity of water exhaled from it in vapour, equals that which is brought into it by the rivers. The Black Sea also has no tides; nor the Baltic Sea, that very large collection of waters. In the Mediterranean, a slight kind of tide is felt in some places, at some times, very irregularly, and only discernible by diligent observation. But in those capacious receptacles of water, the Atlantic Ocean, the Pacific Ocean, and others, the fluid is constantly in motion, rising or falling with little cessation, and with regular and determinate periods: every six hours and a half producing a change in the aspect of the shores. Beside this, every fortnight the tides are more considerable than at other times; and beside this also, at certain periods of the year, they are yet more notorious and extraordinary. It is clear, that no principle in the water itself can cause these changes, in such variety and inconstant regularity: nor any principle in the globe of the earth, or its situations; since these are not so frequently interrupted, but gradually and steadily maintain their progress. We must, therefore, seek some more distant cause; and this we find among the celestial bodies.

The nearest planet to our earth is the moon; and though much smaller than our earth, yet it has considerable (always proportionate) effects, over the whole globe. The solid parts of the globe being firm and inseparable, whatever power affects them, its impulse is distributed throughout the whole, and that proportion of this power which falls to the share of any one part, is trifling, but, the fluid parts of the globe, their union being slight, are easily separable, as if every atom were independent. Here, therefore, we may expect, that appearances will discover the exertion of any power, and here we find, in consequence, the most unlimited mutability.

To render this mutability more conspicuous, let us for a moment, suppose, the whole superficies of the globe were covered with water; no islands, no capes, no promontories, to check its course. It would follow, that whenever the moon was at any supposed meridian, the whole body of water would feel her attractive power, and would *there*—immediately *under her*—stand, as it were, on a heap: her influence, I say, would assemble a great body of water, and immediately beneath her direct and vertical rays, would be the very summit of the hill of water; so to term it. Were the planet's course now suddenly checked,

thus would things continue. Admit this for the present: and survey this globe of water. As we recede from where the moon is vertical, to where she is horizontal, as we increase our distance from the *seat of the moon*, we decrease our depth of water; till being arrived at that part of the circumference of the globe (on the equator, or path of the moon for the present time), where we see her very obliquely, and at length quite horizontally, the water is of less depth than it naturally would be—it is low water. So far all is easy, and requires little mental exertion to conceive.

But though the attractive power of the moon be considerable, yet after it is once counterpoised, by the weight of waters, the more distant water would little feel its influence, and would be little diminished: this tends in some degree, to account for a *second* depth of waters, in that part of the globe which is opposite to the moon's station, in her diurnal rotation: but which we cannot wholly account for, without taking that rotation into our estimate, and remarking the reflux of waters, from the place where they had been assembled by the moon's power: this reflux is considerable, and constant, and is augmented by the change which is continually taking place in the center of gravity, between the two planets of the earth and the moon: all these causes contribute to make a second tide opposite to that point where the moon is exerting her influence.

As the moon proceeds round the earth in her monthly course, she changes the situation of this afflux of waters; and as by the diurnal motion of the earth she seems daily to go round it, the depth of tide accompanies her; and would punctually do so, were it not checked by the following causes: (1.) though the waters feel her influence immediately, yet they must have some time to assemble in, and those from distant parts have sundry impediments to overcome, such as—the resistance of the water before them—the difficulty of rising to a level—and their inclination to preserve the equality of the water behind them. The time of high-water, therefore, in the most open places, *follows* the time of the moon's coming to the meridian about two hours. (2) In countries where the coasts are irregular, that irregularity has great influence; in rivers, or arms of the sea, which run far in-land, the time of high-water varies with circumstances. If the moon took no longer time than the sun to go round the earth daily, the tides would happen every twelve hours; but as a lunar day is longer than a solar day by almost an hour, the interval between the tides is prolonged in the same proportion.

Deeper tides happen in some parts of the month than in others, because the attractive influence of the sun is then to be

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added to that of the moon; shallower tides happen at some times than at others, because the influence of the sun is then *subtracted* from that of the moon. Thus, suppose the moon alone might raise the waters ten feet, and the sun two feet; when these bodies are in conjunction, and their forces consequently united, they may, together, raise the waters twelve feet, on the contrary, suppose these bodies to be at right angles with each other, it will follow that what one would raise, the other will depress, and eight feet will be the height of the tide.

As the moon is not always equidistant from the earth (her course not being a circle, by somewhat oval), she has sometimes more influence than at others; on the same principle, the earth not being always equidistant from the sun, that luminary has sometimes more power than at others: and the perihelion of our planet being in winter, we may in winter expect the greatest force from his attraction. The greatest tides happen about February (before the equinox), and about November (after the equinox), but always dependent on the nearest distance of the moon.

The greatest tide we know, is that at the mouth of the river Indus; where the water rises thirty feet.—What an object for Alexander! who had never before seen such a phenomenon, but whose knowledge was limited to the gentle, and almost motionless, waters of the Mediterranean! no wonder he thought the marine Deities were by some means offended; and endeavoured, by offerings and sacrifices, to avert their impending fury. Suspense, and awe, and curiosity, must have agitated the breast of this intrepid warrior, who, had he endeavoured to assign a cause for this event, had little needed to have sighed for other worlds to conquer,—since even his preceptor Aristotle, was mortified to find it beyond his knowledge. The most remarkable tides are at Tonquin; for here is but one ebb and one flow in twenty-four hours; and twice in each month is no tide, the water being stagnant. These appearances were solved by Sir Isaac Newton, with great sagacity; he attributed them to two tides entering from different quarters; of each of these tides coming successively every day, two at one time greater, two at another time less; the two greater compose high tide; the two smaller the ebb; and the balancing of these tides accounts for the interval of no tide.

Though tides are the greatest instance of the mutability of water, yet others are suspected by curious observers; and could we contrive instruments sufficiently accurate, we might probably discover the same causes producing a wonderful variety of effects. It has been suspected, that, the kind of madness which arises from an accumulation of water in the brain, follows pretty

closely the phases of the moon : and as the subjects of it are usually worse at new, and full moon (the times of high tides), some have hinted that a kind of tide disturbs the seat of the disorder.

We have another phenomenon in extensive oceans, which does not appear in smaller bodies of water : I mean, the SURGES, which, in enormous waves, almost overwhelm the shores. These are most frequent about the equator, and seem to be occasioned by the diurnal motion of the earth, which being most sensible in those parts, has the greatest effect on the restless deep. The motion of the globe is steady with regard to the *terra firma*, but the buoyant waves being thrown forward by this motion, are impelled beyond their natural velocity, and in consequence they exert a force upon the land, which contributes, in succession of ages, to undermine or overwhelm it. Being thrown forward in one part, they are of course withdrawn from some other ; but being a fluid, and perpetually endeavouring to regain the lost equilibrium, their waves roll backward, with little less rapidity than forward ; and by rolling on each other, in the course of so many hundred leagues of water, by the time they reach the shore they become of great height : and upon these shores there is no landing by boats, and little safety for vessels.

Streams, and brooks, and Rivers, enlarge in extent and importance as they proceed ; they gladden the thirsty soil, they refresh the drooping plantation, they furnish beauty to every vegetable ; where they flow life is vigorous, and pleasure abundant ; they seem indeed to destroy, but they really contribute to increase ; and though a few acres might be recovered were a river annihilated, who would accept the exchange ? Such are the gifts of Providence ; partial ills, perhaps, but general benefits : it strikes us evidently in the river, and would do in the ocean, but that the ocean is beyond our calculation. Why storms and tempests ? that like rivers they may do much good at little expence. Such is the appointment of him who speaks the wild waves into peace, “ hitherto shalt thou go, but no further.”





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OF THE ELEMENT EARTH.

THE vicissitudes and changes to which our planet has been subjected, have greatly, I might almost say totally, altered its appearance; so that its original composition is now to be inferred and gathered (and sometimes supposed,) from circumstances which occur but seldom, from facts collected with much care and sedulity, or sought with eagerness and hazard, wherever some chasm seems to hint a probability of shewing nature free from those disguises which are her customary attire. On the surface of our globe, what works, what undertakings, are in perpetual progress, from proposition and commencement, to completion: from completion to ruin and decay. Every animal is by himself diminutive; yet the united, or the successive efforts, of animals, produce no trivial effects in the appearance of their general mother. Some burrow superficially, some dwell deep in dens, some excavate the very rocks; all while they live, consume part of her productions; when they die, they yield a somewhat which furnishes fresh productions for successors. What has been the constant employment of man, (especially), during so many ages? to till the ground; to increase the nobler species of vegetables for his use, or pleasure, or that of the animals he has subdued to his service: hence barren heath has been covered with verdure, cultivation has fertilized the very sands; hence woods of various natures planted, hence rivers regulated, hence canals created, hence waters collected in some places, drained in others; here he wants a pool, there he forbids a marsh; here he deepens a haven, there he repels the sea, and restrains it by a dyke. What a change of the face of nature around some opulent metropolis! the bowels of the earth are ransacked for riches or ornament; and what was buried in obscurity, now gleams in the face of day. These are occurrences so notorious, so regular, and so constant, that to convince ourselves of their influency, needs but ordinary observation.

But more potent principles than these, effect at a stroke, more than all the successive efforts of mankind; and with unabated vigour, with incessant assiduity, they punctually fulfil their employment;

employment: no change of object, no diversity of opinion, no attention to others concerns, interrupts their usual occupation; such are the elements we have already treated on, AIR and WATER. Every stream of air which sweeps over the surface of the earth, carries with it much which has not power to resist its force. Is there a straggling atom of earth? it is whirled away, now here, now there, this spot is deprived of it, that it augments; and trifling as this may appear, the perpetual repetition of it has great effects: producing barrenness where was fertility, and fertility where was barrenness. Nor is this all; for the air, by the constant operation of vapours, showers, rains, storms, tempests, performs by the agency of these meteors, with rapidity, what to itself alone would be tedious. Who has not seen, after a heavy rain, the very surface of the upper grounds conveyed to the lower? evident in the streams running over its surface, in the discoloured water of ditches, of brooks, of rivers. The same event occurs even on the mountain tops, which by repeated rains are gradually diminished. If these scarce-noticed causes produce in time such extraordinary effects, we cannot but attribute yet greater powers to the waters of the sea, whose restless agitation opens or fills, deepens or shallows, gulphs, bays, havens, ports, wherever it has admission. Is it said, these causes are superficial, let us examine beneath their operations?—this is scarce, if at all possible, deep as we dig, we find the traces of water and its power:—the endeavour is hopeless, and rendered more hopeless, by the operations of earthquakes, of subterraneous fires, of volcanos, and many other probable principles, whose concealment is no impediment to their existence deep in the globe. Under these embarrassments, how shall we distinguish Elementary Earth? or is there, or was there ever, one simple earth, the parent of all others, whose plastic principles furnished those varieties which now perplex us? Rocks are earth, equally with sand or clay; yet the obdurate Alps of granite, seem little allied to the crumbling dust of the sand-pit: and who will suppose mines of metals, gold, silver, lead, tin, &c. of salt, coals, slate, and others, who will suppose these to be merely separations from any original parent? and to which, among those we are acquainted with, shall we attribute patriarchal honour?—I consider it as labour lost to examine this question closely: could we solve it, small would be the advantage; and probability seems the utmost extent even of our fortunate researches. To me it seems probable, that earths of various kinds were originally appointed to compose the habitation of man; but that earth to which he ever was, and ever will be, under the greatest obligation,

tion, is that which furnishes vegetables with proper support ; which opens the enfolded seed, nourishes the tender germ, supports the rising plant, and matures the important product, whether salubrious or useful, whether for nutrition or for convenience.

Chymists, indeed, distribute earths into several classes, according to such of their properties as they have discovered ; and it must be owned that this distribution has many advantages ; but it is difficult to say which of these classes is (naturally) simple and pure earth ; since, when submitted to the test, they furnish a variety of products which proves they are compositions : and this variety consists, not only of different earths, but of other elements ; of air, and water, we know ; and why not also of fire ?

A very striking property of most earths is, that they are capable of *vitrification* : that being submitted to various degrees of fire (some of which are highly intense) they liquefy, and run into a kind of glass, more or less transparent, more or less hard, of various colours, and so on. This has induced some persons to imagine, that the whole earth was once a fluid of burning matter, not unlike glass ; which, as it cooled, became at length fit for the residence of animal and vegetable life ; it is true, say they, it was a long time in cooling,—and it continues cooling still ;—when (according to this hypothesis) it shall be quite cold, shall the general conflagration ensue to destroy it ?

This presents a specimen of the creative powers of human imagination : Earth is vitrifiable, therefore it has been vitrified ;—when it was vitrified, no one doubts it was a seat of heat and fire ;—right, says another, it was therefore a comet ; comets are seats of heat and fire :—granted, is the reply, if you admit that both comets and planets, but planets especially, were formerly parts of the solar luminary, that origin of heat and fire. Such is mankind ! O could some happy genius tell us, by calculation, at what period the next comet shall graze the solar surface, and strike off fresh planets to join the revolving chorus ! who would not wish to live when that encounter happens ! who would not wish to risque a situation on that heavenly messenger, which shall thus shock worlds into being ! But alas ! no mortal has hitherto been favoured with the sight ;—and, ere its next return, mortality shall be swallowed up of life !

VITRIFIABLE EARTH furnishes many conveniences and elegancies to mankind ; since the articles made of glass, to name no other, are very numerous. But some kinds of earth, being submitted to the action of fire, become merely a kind of crumbling powder,

powder, and these are termed **CALCAREOUS**: such are chalks lime-stones, and even marble. **GYPSEOUS EARTH** forms plaster of Paris; and has the singular property, after it has been burnt to a powder from the stone which furnishes it, of becoming a kind of stone again, by the addition of water; and of swelling as it dries: a circumstance not, as I recollect, belonging to any other substance. This renders it extremely convenient to form casts from molds, &c. as hereby it insinuates itself exactly into every crevice, and becomes an accurate counterpart of the mold which contains it. **MAGNESIAN EARTH** is distinguished by several properties; this earth is seldom (naturally) seen by itself, but is usually obtained by separation from others. **ARGILLACEOUS EARTH**, or **CLAY**, seems the nearest approach to that which furnishes vegetables with support: and yet pure clay possesses few fertilizing principles, nor do we ever find, in such pits as have been opened, that any kind of verdure covers them, till a proper time has elapsed, and they have acquired a somewhat of which before they were destitute.

It is not improbable, that all the soil in the world with which we are acquainted, has in a like manner acquired a somewhat of which at one time it was destitute. It is in vain to refer to any period beyond the flood, as furnishing an original and native vegetable earth; but it seems likely that, subsequent to that terrible convulsion of nature, the trees and plants, their leaves, the more tender kinds of grass, &c. rotted into a pulp, and dried by degrees. We are not under the necessity of supposing every spot was utterly destroyed, but, consulting probability, we may admit, that then as now, the spoils of former vegetables became the support of their successors: and this seems the true origin of the most fertile soils: of soils the most fertile without human assistance and art. Such we find in regions where the human foot has never trod; where, during a long lapse of time, decaying verdure has accumulated, and enriched at its decease the earth which supported its life. Here reigns excessive luxuriance, and superabundance of vegetation, plant upon plant, below impenetrable, without the assistance of a hatchet to open a passage, and rising over head to the very tops of the tallest trees,—a canopy so matted together and interwoven, as to exclude the light of the sun; and however cleared away at bottom, yet upheld by mutual support at top. This soil is so rich, as to require impoverishing; and the planter knows, that unless he mixes a proper proportion of sand with the earth he cultivates, his corn, &c. will shoot rapidly into height, become rank, and spend, in appearance, that spirit and strength, which should be its richness and value. The very

grass

grais here, rises to the height of a man, and must often be burnt to retard vegetation.

From what has been said, it seems to follow, that elementary Earth is not now within our power: we find indeed, earths of various sorts, each valuable in its place, and all necessary to a complete union and combination.—Some we find rich, almost unctuous, others steril, dry, hard, and intractable. Some united into immense masses, solid and ponderous; others in small grains, and almost atoms, the dust of the earth! Some we find barren, others fertile,—shall we enquire upon what principles then depends fertility? and how far is earth concerned in promoting it?

That earth has some share in the vegetables it produces, seems at first sight evident, from the earth yielded by all vegetables (more or less) upon reduction to their principles: but this seems on the other hand contradicted by experience, which asserts that the earth wherein vegetables grow, loses nothing of its weight or bulk, in a course of years; but, so much as it was when first it received the seed, so much it continues undiminished. This is apparent to a nicety in the orangeries abroad, where each tree being planted in a distinct box, the increase of earth (by deposition and decomposition of the fallen leaves of these trees) would be evident: as also its decrease, if the plant absorbed it. But it should seem, that after allowances made for loss by dust, &c. blown from the surface of its box, that famous orange tree the Great Bourbon itself, though, three hundred years old, has not diminished that earth it was planted in.

The repeated supplies of leaves, flowers, and seeds, with which the trees are annually arrayed, and which they afterwards cast off; together with the perpetual dissipations of the sap, whose freshness we experience, not only in forests, but even in a timber-yard, and for a considerable time after wood has been felled; are such consumptions, as would exhaust the earth in time, were they furnished from her own substance. If the repeated loppings of thickets and forests, were all to be thrown together for some ages, they would form piles as high as the mountains themselves, on which they were cut; and if the earth either produced the woods, or nourished them from her own bowels, these would all be consumed by degrees. The mountains by being constantly undermined, and wasted by the processes of so many deep roots, would be insensibly diminished. Their evacuations would sink them from age to age, and the smaller eminences would have been laid level with the plains long ago.

“The earth, which nourishes our forests, sustains no dissipation of its substance, but continues undiminished, like the earth in the box of an orange-tree.”

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“And

"And yet the orange-tree has acquired considerable accessions of growth; and has likewise produced leaves and fruit repeatedly. These have weight proportionable to their substance: from whence then do they receive it, since the earth continues as heavy as it was at first? The materials of these growths must be imparted from other sources."

This fact has, in other instances, been accurately investigated; the earth previously weighed to a grain, and every precaution taken: the issue has uniformly been the same. We conclude, that earth only furnishes a convenient and necessary channel, or means of conveyance, to those principles which promote vegetation. We see, every day, many flowers, especially bulbous-rooted flowers, without the assistance of earth, but merely as nourished by water in those glasses which decorate our mantle-pieces; we see them daily flourish in every variety of tint and colour; nor perhaps has it escaped our notice that many family esculents (onions, for instance especially) will sprout and grow while *hung up*, free from every supposable communication or contact with earth. We have here appealed to subjects with which we are familiar, and which having originally grown in earth, may seem to require a connection with that element, as most natural, and most necessary, for their further growth: but it is with great probability supposed, that many vegetables growing in the sea, whose leaves appear and swim on its surface, have never been attached to earth, but may be considered as germinating and increasing in water only. If it be said that the seed of such plants may fall to the bottom, and there first unfolding, may originate from the earth, and afterwards be torn from it by currents of water, we grant it may; yet if these plants, from this supposed state of immaturity and weakness, arrive at their perfection while floating on the waves, they may, with at least equal justice, be deemed the offspring of water as of earth: we know, indeed, that a sprig of mint (and other plants), after being taken from the earth, will shoot out roots and grow in water; but it is with great difficulty such a sprig can be returned from water to its native bed, with advantage: such plants seldom survive the change. Upon the whole we may, without injustice consider earth as furnishing, (1.) a proper bed wherein plants are deposited; (2.) heat and warmth in due proportion for maintaining the life committed to its care; (3.) a regular draught of those nutritive juices which it receives from other quarters.

(1.) The texture of that earth wherein vegetation flourishes, is neither so strong and hard, as to forbid the penetration of the roots, and their smaller fibres; nor so loose and dusty, as to part

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with such roots by the agitation of gentle breezes ; not stiff like clay, nor crumbling like sand ; but of a due consistence, and, as one may call it, *temper*. (2.) There are soils so cold in themselves, that labour is lost in attempting to ameliorate them ; these are consequently disposed to barrenness ; others are naturally warm. But in another sense the earth is *warm*, as it receives, and holds for some time, the ardent beams of the sun, and these it distributes as occasion requires ; regularly, constantly, probably frugally, but certainly effectually, and without reluctance. Were all the heat of the sun *at once* imbibed by a plant, it would be parched and consumed ; or if it survived, when the stock was exhausted what penury would follow ! But the earth, gradually warmed by the solar beams, imbibes them ; and when the sun is withdrawn during night, maintains a steady warmth around its plants till the sun returns ; and this kind office it continues, till the plants, having reached maturity, fulfil the reapers hope. (3.) On much the same principle, the distribution of rain, &c. by the earth is beneficial : a flood of rain does much less service than if it were gentle, because it runs off the earth rapidly, rolling superficially over it ; whereas gentle rain gradually sinks to a proper depth in the ground rendering it a kind of reservoir, from whence the plants, by their roots, may draw a sufficient moisture for a considerable time.

That the intervention of the earth is necessary, appears from what has been just observed ; chiefly as it affords a kindly-adapted medium and passage to those principles of vegetation, of which itself furnishes but a diminutive share ;—every element, perhaps, partakes in the formation of a vegetable ; air is notorious, water is very abundant, earth has some share ; and without fire, no plant would arrive at maturity, would ever be ripened or compacted.

We admire the productions of the earth ; and we dwell on their characters, and qualities : the lofty tree and the beauteous flower, the sturdy oak and the fragrant rose ; but we seldom reflect on the near alliance between them and ourselves. I was perhaps wrong in saying, “ our greatest obligations are to that earth which supports vegetables ;” ought I not rather to have said, that earth which composes ourselves ? which, animated in mankind exhibits every varied excellence, and every captivating grace, which sparkles in the eye, or glows on the cheek, exalted beyond the capability of flowers, were loveliness only regarded : but if social manners, and affections mild, adorn this exaltation, what has not earth to boast ? or, when constancy and courage, genius and skill, depth of thought, of research, of understanding, connect with a little earth, in what is the lofty tree, the sturdy oak, comparable to this ?

We have seen that earth itself can produce no plant, can form no blade of grass; barren and vacant alone, but the means of production and support to all things; and, when commissioned, the residence even of thought and intelligence. See what supreme Power and Skill can do! But though we do right to admire these effects, we may reasonably hope to behold infinitely greater wonders, when this clothing of earth shall quit us; when we shall return to earth what for a little while we had borrowed; and when the clay, whose medium is now necessary to communicate our ideas, our sentiments, our conceptions, shall be deemed no longer worthy our residence; for, though wonderfully wrought and formed, replete with contrivance and ingenuity, actuated by, and actuating a thousand springs, all astonishing in their construction, in their effects, in their composition, in their sympathy, and in their union, yet this fabric shall be dissolved, and earth return to earth, and dust to dust.—What! shall this composition, this terrestrial master-piece of the Divine Workman, omniscient in wisdom! shall it be lost, be deemed unworthy admission among his superior exertions of skill? No! it shall be purified by dissolution, then be adorned with splendor, be surrounded with glory, be ennobled with dignity, and then, earth—earth shall be honoured among the most honourable works of Deity, and perhaps be remarked by admiring angels, as a transformation once unthought of, unlooked for, and now beheld with surpassing astonishment, and joyful gratulation!

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OF THE ELEMENT FIRE.

THERE is nothing more difficult than to confess ignorance with a good grace: how often do we see hints, innuendos, and even shrugs and grimaces, employed to palliate or disguise the absence of accurate information! and this too, on subjects beyond the powers of humanity, where accurate information ought little to be expected. There are many things whose uses we enjoy, but their causes are hidden; we receive from their services many benefits, but the manner in which we receive them, or their mode of action, is secret—this secrecy arises from various reasons; either they require for investigation a length of
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time which exceeds the usual limits of human life, or at least exceeds that proportion of time and study which prudence permits individuals to bestow,—or they are attended with difficulties, or with danger. Who can justly expect that mankind should fathom the ocean, and explore its recesses? should discover all its inhabitants, their abodes, their manners, their properties, their connections?—Till man becomes an aquatic, very limited knowledge of these must content him. With equal, with perhaps superior difficulties, we investigate the element FIRE. It is true, fire is all around us; is necessary to our existence; banish it we die: on the other hand, collect it, too much overwhelms us with destruction: and yet, when we ask what is fire, who can completely answer the question?

I shall not profess to know, what probably never was, nor ever will be known; but without endeavouring a display of recondite knowledge, shall offer a few simple remarks, arising naturally from the subject under consideration.

We must in the first place, dismiss from our ideas of this element, what in reality makes no part of it; *fuel* is not fire: the coals burning in a grate, are consumed by fire, and they afford sustenance to fire; but it is highly improper to say, an element consumes itself, or sustains itself.—Our food is not ourselves, though it is the means of support and prolongation of our life. Nor is the *light*, which usually accompanies fire, any part of the element: on the contrary, it may justly be suspected, that intense light (such as we may conceive of but not support) should rather destroy fire.—We shall hereafter see clearly, that the first of these positions is true. I shall at present only explain the second. If we can prove that light is not fire; I presume we may safely assert that fire is not light.

The first instance of the separate existence of light is in the lunar rays; which, at full moon, are, as we know, abundant, and even sufficient for the purposes of life; they are clear, and not without activity; yet, when condensed by a burning glass, five hundred or a thousand times, so as to be extremely bright and vivid, they excite no heat, nor do they in the least raise the liquor in the thermometer.—Reason a little upon this,—the most sensible instrument human skill can devise,—which is affected by the breath, by the approach of the hand, by the most subtle vapour, yet remains unaffected by a *condensation* of the lunar rays. Rays from the moon are merely reflections of rays from the sun; there is no supposable quality in the moon to alter or change their properties; all that planet can do is, by the sphericity of its surface, to diverge and expand them; which is merely

merely a separating of ray from ray, or introducing distance and interval between the reflected rays, but makes no change in any one ray, considered in itself: it follows, that rays from the sun are *light*, not fire or heat.

Is it inquired, whether, on our own terraqueous globe, there be places where light abounds in regions of cold? we answer, many: every mountain top bears evidence of this; but it is (especially) demonstrated on the summits of exceeding highly elevated mountains. We instance, the *Peak of Teneriff*, a mountain by itself, on an island. Below, are sultry exposures and excessive heats, here the labourer faints, here the lightest clothing is thought too heavy; cool grots, and shady retreats, are here the only enjoyment of life: but ascend the mountain, the air becomes temperate, then cool, then cold, sharp, frosty, severe.

—Here all its winter; here dwell eternal snows; yet light is abundant! Still more remarkable are the tops of the *Andes*, of the *Cordilleras* (in South America); for these mountains are sufficiently large to afford spacious plains, and extensive levels: here is a serene sky, ever blue, ever bright; no vapour rises to this elevation, nor cloud obscures the splendour of refulgent day, never moderates the excessive—heat? Oh, no! the warmest furs, the most solid clothing, the winter dresses of polar climates, fail here, and cramping cold pierces the very bones. Here, if any one dies, the body remains intire, embalmed by perpetual cold; it suffers no change, because the alternation of warmth is unknown: and of those who pass these ridges of mountain upon mountain, without paying their lives for the journey, many are maimed; they lose their fingers, their toes, or other extremities, whose distance from the fountain of life subjects them to a diminution of vital heat.

Ætna, you know, is a volcano replete with the materials of fire; yet high on *Ætna* ever reign perpetual snows. After this it is little to mention that a friend of mine, in passing the Pyrenees, experienced the air “penetrate him through and through:” no defence could exclude the cold.

It is not without hesitation, I introduce the mention of *phosphoric bodies*, which shine in the dark; some of them, by their qualities, seem pretty much impregnated with fire, united with light: but others, have no sensible property of fire, but seem merely lucent. Such is the Bolognian stone, and other Marcasites, which, covered over with their own dust, and put into a fire, afterwards retain the property of shining in the dark. The dust of these stones, so prepared, if sprinkled on linen, woollen, &c. shines and sparkles in every form, according to the

the pleasure of its employer ; but it neither sets the linen on fire in any manner (that ever I heard of) corrodes, or injures it. What is more extraordinary, if one of these stones, thus prepared, lose its virtue by injudicious exposure, and continue so long time, on being laid in the solar beams for a few hours, it will shine afresh. Shall we say it imbibes a quantity of solar beams, which it strongly retains, and visibly emits when in the dark? *i. e.* in the dark they become visible by contrast ; perhaps the stone is always either imbibing or emitting them ; but the first we cannot expect to see, nor the latter, unless all other light be excluded.

There are many natural phosphoric substances which shine in the dark ; such as glow-worms, rotten wood, corrupting flesh, fish, &c. Art has composed a variety of others ; and indeed it is found, that from almost all substances, animal and vegetable, the principles of phosphoric light may be extracted : so universally is this fluid imparted, one would think it a necessary ingredient in their existence and vitality.

It is time now to inquire, whether fire be ever found separate from light ? Fire is never found alone, we are unable to say, "this is a lump, or this is a drop of fire ;" but it is always combined with some other body. Melted metals, such as lead, &c. are doubtless held in fusion by fire ; but melted metals do not shine ; shining, then, *i. e.* light, is no constant property of fire ; but though its customary companion, in this instance deserts it. Other bodies, in a state of fusion, agree with this experiment ; the most solid ice submitted to the force of fire liquefies, the liquor therefore contains fire ; increase this quantity of fire, heat the water, boil it,—boiling water does not shine : here again fire is without light.

It will be granted, there is less fire in water in its natural state, than when boiling, as there is more fire in water than in ice. This may suggest the manner how another fluid (the air) is affected by fire, *i. e.* that it always holds a certain quantity, (else it would perhaps be frozen,) but not enough to render its presence visible ; and even when, by great heat, air may be said to boil, its motion is very evident by the tremulous effect it produces on the passing rays of light ; but it does not shine : and we know that a room may be rendered extremely hot, even to suffocation, and far beyond the degree of heat fatal to life, yet the air in that room shall manifest no inclination towards shining ; nor if we suppose a spectator to examine it, would he see in it any difference indicating that it was replete with fire.

As the atmosphere may contain a great quantity of fire, or the air it contains may be more active, and agitated, at one time than

than at another, so it may become more sensible by its *heat*; I say, it may affect us with a sensation, which we call heat. Heat and cold are relative sensations; what at one time seems hot, at another time seems cold, according to the temperature of the person who judges; heat therefore is the effect of the presence of fire, as experienced by us.

If the air were always still, motionless, and quiet, we should never discern its presence, should never know whether we were surrounded with such a fluid or not; very possibly, we should never suspect the fact; but when air is put into motion, we are well assured of its existence, though it be invisible. Or, when water is equally distributed and suspended in the air around us, we are totally ignorant of its situation; nor till it becomes visible in vapours, mists or clouds, does it come under the cognizance of our senses, and afford proof of its suspension and elevation; thus it appears, that our senses are the ministers of information; we recollect also, that to render the tides observable, *oceans* of water are necessary: had we possessed only streams, we should have little imagined such an impulse upon water as produces the tides.—We infer, that a fluid, &c. may exist undetected by us, unless its quantity be sufficient to excite our observation, or unless, by some *impulse*, force, or power, a smaller quantity acquires some property, which by rendering it noticeable, enables us to determine concerning it. In proportion to the thinness and fineness of such a fluid, the probability of our ignorance of its existence increases. Perhaps I might with little risque assert, that we are indebted to accident for our knowledge of the finer fluids, such as the electric, the magnetic, &c. as well as for many of the more surprising properties of those which are our familiar companions.

The fluid, Air, we can feel and hear, but neither see, nor taste, nor smell; Water is subject to most of our senses, to tasting, to feeling, to smelling, to sight; but Fire seems to be a fluid, neither to be seen nor tasted, nor smelt, nor heard, but it becomes our acquaintance through the medium of feeling; by this single sense therefore, accompanied by observation and reflection, we are to be directed in our inquiries after the properties and the effects of fire.

If after the endeavours of almost all our senses, and after experiments varied almost *ad infinitum*, we are obliged to confess that the secrets of Nature escape us, that the elements Air and Water are beyond our conception in many respects, need we wonder that when, by one single sense alone, we are capable of investigating the element Fire, we should labour under uncertainty or mistake?

Neither

Neither need we wonder, that different opinions on the subject should divide philosophers; that what seems plausible, if not altogether certain to one, should to another seem weak and inconclusive; that the happy ideas of one are esteemed frivolous by another, and that while wandering each in his own way, that way should appear most direct to himself, though intricate and perplexing to his neighbour.

From the 14th section of Sir *Isaac Newton's Principia*, we learn, that the motions of small bodies, when attracted perpendicularly towards any surface, according to any law, are similar to the motions of the rays of light, with respect to the fundamental properties of inflection, reflection, and refraction: from hence chiefly, as well as from other arguments, is inferred, that rays of light are small corpuscles, emitted from shining bodies, and moving with uniform velocities in uniform mediums; but with variable velocities in mediums of variable densities. This being admitted, it will follow, that in whatever quantity the rays of light are made to move in a medium of an uniform density, they will not agitate the particles, or produce any augmentation of bulk in that medium. If the atmosphere was reduced to a medium of an uniform density, surrounding the earth every where to the height of five miles, it would be expanded in bulk, or warmed, only at its outward and inward surface. The sun's rays by coming out of a *vacuum* into a denser medium, would be attracted by the particles composing that medium; and, since all attraction is mutual, they would excite a motion, an expansion, an heat, at the outward surface where they entered: from thence they would proceed uniformly, without producing any effect, till they came to the inward surface of the atmosphere contiguous to the surface of the earth, where they would undergo another acceleration of velocity, and would excite another degree of motion, another degree of expansion or heat. Such an atmosphere would be coldest in the middle, the heat decreasing from each surface. We may, perhaps, from what has been said, conceive, in some measure, how bodies are expanded, heated, and volatilized, by the agency of the particles of light. These particles act upon the minute constituent parts of bodies, not by impact, but at some indefinitely small distance: they attract, and are attracted; and in being reflected, or refracted, they excite a vibratory motion in the component particles. This motion increases the distance between the particles, and increase of the distance between the constituent parts of any body, is an augmentation of bulk, an expansion in every dimension,—the most certain characteristic of fire. This expansion, which is the beginning

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ginning of a disunion of the parts, being increased by the increasing magnitude of the vibrations proceeding from the continued agency of the light, it may easily be apprehended, that the particles will at length vibrate beyond their sphere of mutual attraction, and thus the texture of the body will be altered or destroyed: from solid it may become fluid, as in melted gold; or from being fluid, it may be dispersed in vapour, as in boiling water.

According to this theory, we must infer, that the constituent parts of all bodies are in perpetual motion. The temperature of the atmosphere is different in different latitudes, and it changes almost every instant, in the same. The temperature of bodies is ever proportionable to that of the surrounding atmosphere, and from thence it must be perpetually varying. The bulk of every body is proportionable to its temperature, and must therefore be subject to a perpetual vicissitude. At this instant the body will be in an expanded state, in the next instant, its heat happening to be diminished, it will be in a contracted state; which variation of dimensions cannot be effected without a perpetual vibratory motion of its constituent parts.

It being established then, that the rays of the sun, even in their most condensed state, as in the focus of a burning speculum, do not otherwise produce heat than as they excite a motion more or less violent among the constituent parts of bodies; and the effects of culinary fire, of that produced by friction, or by the impact of hard bodies, being similar to those produced by the agency of the sun's light, it may be conjectured, that they are produced after a similar manner: and that fire is nothing distinct from the parts of bodies put into motion by various causes, as the impulse of light, friction, percussion, putrefaction, attraction of cohesion, &c. and consequently that it may be mechanically produced, altered, or destroyed in all bodies, with greater or less facility, according as the parts of the body are more or less disposed for motion.

This conclusion seems to be consonant with the principles of the received philosophy. Newton, in his 5th quære annexed to his Optics, asks, do not bodies and light act mutually upon one another? that is to say, bodies upon light—in emitting, reflecting, refracting and inflecting it; light upon bodies—for heating them, and putting their parts into a vibratory motion, wherein heat consists?—Such was the opinion of Newton.

Boerhaave thought that fire is a fluid of a nature peculiar to itself; that it was created such as it is, and cannot be altered in its nature or properties, can neither be destroyed nor produced; that it naturally exists in equal quantities in all places; that it is

wholly

wholly imperceptible to our senses, and only discoverable by the effects it produces, when by various causes it is for a time collected into a less space than what, from its tendency to an universal and equable diffusion, it would otherwise occupy. All the bodies which are situated in the immensity of space, may, according to this opinion, be divided into fire expanding all other bodies, and into all the other bodies which are not fire, but resist its action. The matter of this fire is not supposed to be derived from the sun in any wise; the solar rays, whether direct or reflected, are of use only as they impel the particles of fire in parallel directions: that parallelism being destroyed, by intercepting the solar rays, the fire instantly resumes its natural state of uniform diffusion. Consistent with this explication, which attributes heat to the matter of fire, when driven in parallel directions, a much greater must be given it, when the quantity so collected, is amassed into a focus; and yet the focus of the largest speculum does not heat the air, or medium in which it is formed, but only bodies of densities different from that medium.

The author of the *Lettres Physiques* is of opinion, that the solar rays are the principal cause of heat; but that they only heat such bodies as do not allow them a free passage. In this remark he is agreed with Newton: but then he differs totally from him, as well as from Boerhaave, concerning the nature of the rays of the sun. He does not admit the emanation of any luminous corpuscles from the sun, or other luminaries, but supposes all space to be filled with an æther of great elasticity and small density, and that light consists in the vibrations of this æther, as sound consists in the vibrations of the air; the particles of the one medium exciting, by impulse upon the organ of vision, the idea we call light; the particles of the other medium exciting, by impulse on the organ of hearing, the idea we call sound. But as a bell will not of itself begin those vibrations by which the air is agitated, nor continue with equal intensity the vibrations, when once excited, without the concurrence of some mechanical cause; so neither will the sun either begin or continue his vibrations, by which the supposed æther is put into motion, without a similar mechanical agency.

In ascending from effects to causes we must ever arrive, upon whatever hypothesis we proceed, at some first cause, which does not admit an explanation from mechanical principles; this is evidently the case in the present inquiry. On Newton's supposition, the cause by which the particles of light, and the corpuscles constituting other bodies, are mutually attracted and repelled, is uncertain. The reason of the uniform diffusion of

fire, of its vibration, and repercussion, as stated in Boerhaave's opinion, is equally inexplicable; and in the last mentioned hypothesis, we may add to the other difficulties attending the supposition of an universal æther, the want of a first mover to make the sun vibrate.

Thus we see, that in every hypothesis there are difficulties:—for my own part, I think much is to be said for that of Boerhaave;—but then the *universality* of this fluid, which he supposed to be distributed throughout space, this I would restrain to our globe and its dependencies, and suggest another fluid as supplying its place in the celestial regions. I am unwilling to go beyond the limits of our habitation, for those elements which seem necessary to render it habitable; and if we may suppose it complete in itself, with only one exception, which exception is supplied from that magnificent fountain of light, the sun, I think we approach the nearest to a just idea of the plan adopted by creative wisdom. But though we suppose this fluid to be in its natural state, generally, uniformly, and tranquilly diffused; yet when a number of bodies of various textures are immersed in it, it will, like any other fluid, prefer those to which it is best adapted, and which are most capable of attracting, of imbibing, and of detaining it. Some will readily receive it, and equally readily dismiss it (much as the phosphoric stone we have mentioned, does with respect to light); others will not only strongly retain it, but will imbibe a much greater quantity of it, will saturate themselves with it! and when thus *drenched*, as it were, and thoroughly replete with this element, they may affect the rays of light around them, may either attract and imbibe them, or emit what they have already imbibed in very large quantities, and thus render visible the fire, by its effects upon light. For I think we cannot say of fire, it shines, shining being exclusively the property of light; but we not only may, but must say, that in many instances the presence of fire is manifested by light, or that light is so affected by fire, as to acquaint us of the presence of its companion.

On these principles may be readily granted, that some bodies are more combustible than others, that they more freely take fire, are capable of greater degrees of heat, hold heat longer, and many other particulars.

We advert now to some of those effects of fire, which, whether they are deduced from one hypothesis or another, are claimed by each as favourable to itself; and which are so evident and constant, that none can contradict or deny them, or expect to establish any scheme to which they are opposed.

It is usually said, there was a time when mankind had no knowledge of fire (and a very strange story is found on the subject in Vitruvius); it is certain, that the human body is naturally ill fitted to support too much of this element. It is said BOERHAAVE thought half the disorders of the species arose from too great a proportion of warmth; and we well know, that those exposed to the most rigorous seasons, are neither the least healthy, nor the shortest lived; they receive little or no injury from cold only; the vicissitude of the weather seems to be their greatest enemy. As it was impossible that a person should rub with any violence, and for any continuance, two pieces of wood together without producing heat (perhaps I might suggest, as yet simpler, the very rubbing of his hands together), if this was to him an agreeable sensation, he might easily continue it, and by friction excite *flame*; this is done daily among the Esquimaux Indians, in North America, who, by whirling rapidly a piece of wood, by means of a thong, excite flame in other wood against which it turns. One might pursue this train of thought somewhat further, might ask, whether this supposed original fire-producer considered his acquisition as a friend or a foe, as useful or hurtful: was he (as it is said the inventor of gunpowder was) the victim of his own discovery, or did he happily apply it to moderate the rigours of winter, and to cheer, with sprightly lustre, the heretofore gloomy habitation? A word by the bye; man is the only being upon earth capable of producing fire (*i. e.* flame, flame is ignited vapour); and the only which knows how to maintain it when he has got it: for though many animals love heat, and the oran-outangs in the woods surround the fires which the negroes have left, and enjoy their warmth; yet they have not sense enough to prolong the fire, by bringing sticks or leaves to maintain it, though they see the negroes do so, but suffer it to expire contrary to their wishes.

We have suggested that fire, like air, is distributed throughout the globe: like air it is probably extremely *elastic*; and also extremely *penetrating*. That it is elastic, I think, appears from what we have said of the elements air and water: these are highly elastic in certain circumstances, but these circumstances always imply fire; fire therefore seems to be the cause of their elasticity—surely not without being elastic itself. As to its powers of penetration, they very far exceed those of air and water. The polished marble sides which adorn a chimney, are impenetrable to air, and to water, but not to fire. Observe how they begin to be warmed, when the fire in the grate is lighted; as that augments they are heated; and in proportion to the vivacity

ty of the fire, and to their exposure to its influence this heat penetrates them, to any supposable depth.

To penetration we must add (say some) a corrosive quality, whereby like certain acids (aqua fortis, &c.) it consumes what it seizes; while others think that an intimate and general penetration, must needs tend to a separation of the parts of any subject. Thus water penetrates some kinds of clay, till they become crumbling and rotten; shall we say it has the same effect on wood? What hinders our surmising that fire penetrates so irresistibly, as to perform *suddenly* what to other elements requires time, and repetition? But observe, that though fire in excess may be thought to consume all things, yet in moderation its effects vary; some it melts, others it hardens, according to what principles abound in the subject. Its general endeavour seems to be, to loosen all things, to uncombine every combination, and to return the elementary particles to their proper elements, by dissolving the bond which held them together. By fire, metals quit their principles, and by calcination become earths or glasses; earths become powders, or run together into fluidity. The principles of vegetables and animals are distributed by fire; earth has its share; so have air and water: in general, whatever fire can thoroughly penetrate, it also divides and separates into as minute parts as possible.

That kind of fire we are commonly acquainted with, will not burn without access of air; we observed formerly, that pure air revived flame; and the proportion of this in atmospheric air may well be thought to feed it. A lighted candle quickly expires under the exhausting receiver of an air-pump, because it quickly consumes that portion of air which is adapted to its maintenance and support. The same effect invariably attends the exclusion of air from any kind of fire, large or small. On the contrary, fire is greatly animated and invigorated by fresh supplies of air, because it receives the influx, as well of what fire the air contains as of that purer kind of air which is so greatly its friend. This clearly appears in the effects of the blow-pipe, at the enameller's lamp; but the humbler instance of the common bellows proves the point.

A very remarkable property of fire, is the expansion which it communicates to bodies containing it; this is evident in an iron bar, or heater, and when it was the fashion to keep the tea-urn hot by introducing a heater, the dilation of the heated iron was an object of familiar remark. The same iron which when cold passes through a given aperture, when red hot exceeds those limits and refuses to pass. This dilation, or spread of the parts of bodies

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dies, which invariably occurs, whether a body be hard or soft, light or heavy, may perhaps be esteemed the most certain proof of the presence of fire, and serves to mark its variations within certain limits: it ensues as well from the heat occasioned by the impulse of the solar rays, as from that of common fire. Dr. Long mentions his having exposed a large slab of marble in the sun-shine during the heat of the day, then suddenly throwing a great quantity of cold water upon it, it was found, by measurement, near half an inch shorter in its cold, than in its heated state. This effect of fire is notorious to all engaged in the more delicate parts of clock and watch making, inasmuch that it is necessary to correct the too great expansion of one kind of metal, by accompanying it with another kind of metal, less susceptible of the influence of fire.

There is something extremely entertaining in the inspection of a *Pyrometer*, or instrument for measuring the degrees of fire; and by this instrument we find, as indeed might be expected, that closer grained substances, such as metals, are most expansive; while those more porous, such as woods, are little dilated.

But both metals and woods have naturally their portion of fire, which is supposed to enter into their composition in a compact, condensed, fixed state; whereby most, if not all its properties are concealed from us; and (as in the instance of air, &c.) we should not suspect its presence, till upon reducing the subject to its principles, we find effects not to be accounted for without it.

Of itself, in its natural state of uncombined expansion, fire is not esteemed capable of shining, or burning; but when chemically conjoined with other principles of bodies, it conceives and continues those motions by which bodies are made to burn, to consume away. All bodies are more or less susceptible of combustion, according to the quantity of this latent fire which enters into their composition, or the degree of force with which it adheres to them. In the act of burning, and very probably during the fermentation, and putrefaction, and chemical solution of various bodies, it recovers its fluidity, is expanded and dispersed into the air, or combined anew with substances to which it has an attraction.

The instance of sulphur is the clearest I know; I need not endeavour to prove, that burning sulphur emits a powerful vapour, offensive to the smell, and to the lungs; every lighted match demonstrates the position. This vapour collected, is the vitriolic acid; but this acid is itself incapable of combustion, and rather extinguishes than promotes flame in other bodies. *Something else*, therefore, enabled the sulphur to burn; but what? no atoms remain

remain, nor foot.—Charcoal burnt taints the air with an offensive smell, but yields neither watery vapour, nor sooty impurity; a few white ashes are all its remains, and these are incapable of burning; what then enabled the charcoal to burn? Some metallic substances burn bright, others moulder away rather than burn; most of them, when in the open air, submitted to the action of fire, lose their metallic appearance and become earth? There was then *something* which was so combined with such earths, and had such effect upon them, as totally to vary their appearances; this something, is thought to be the inflammable principle, or fire; this latent fire is never visible alone, yet is ever powerful in combination. Latent fire was formerly known by the name of *phlogiston*: but is lately considered as greatly, if not solely composed of pure, or inflammable air. It is natural to enquire, respecting certain metallic earths (which nobody indeed would conceive by their appearances to be metallic), whether they can be restored to their metallic forms?—The answer is, Yes, with little trouble. The earth of lead, exposed to a strong fire, in conjunction with any body or substance replete with (*phlogiston*), the principle of latent fire, will deprive that body of its principle, will assume it itself, and regain all the properties and appearances of lead. And this it will do, whether such substance belong to the animal or vegetable kingdom, whether it be charcoal or fat, or any combustible substance whatever. The charcoal, &c. will become as if it had been burnt. By the same process, by the union of this principle to the acid obtained from sulphur, a real sulphur may be re-produced.

These instances may shew the actual existence of such a principle, and suggest its innumerable combinations. Whatever we examine, admits more or less of this ingredient; metal is not metal without a portion of fire, neither is flesh flesh, nor a plant a plant, nor water water, nor air air. There seems to be but one fluid independent of fire, and which perhaps is the great agent in producing every effect, I mean LIGHT; which yet has such affinity, or attraction to fire, that to mortal eyes they appear the same; only distinguished and separated by those, who having occasionally discovered them apart, have been induced to examine them under various forms, have traced them through various disguises, and at length have proved them essentially different, and in many respects dissimilar.

There is not infrequently a kind of jealousy where art is exhibiting its performances: the mind naturally supposes the artist takes every precaution to insure the success of his experiments, and fancies that to such and such peculiarity, perhaps singularity

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of circumstances; much of that success is owing. I say, upon difficult subjects, somewhat occult is often attributed to management; let us hear what simple nature says on the subject of fire. Fire is produced spontaneously from *vegetables*: from hay, for instance, formed into a stack without being properly dried,—for if properly dried *i. e.* if totally deprived of water, it would remain secure from taking fire. Some water therefore seems *necessary* to produce fire; but too much prevents it. *Animal* substances, laid on heaps have been observed to take fire; M. Montet reports, in the “History of the Academy Royal of Sciences, 1776,” that small *stuffs* called *imperials*, kept in heaps, took fire of themselves. Of such advances toward taking fire, as may be evidently sensible by heat, many instances occur: The heat occasioned by fermentation, by putrescent dunghills, and many other articles, is notorious. In general, we observe that under some shape or other more or less *moisture* (*i. e.* water) is necessary, and that subjects whose natural principles are most aqueous, are most apt to be heated. Paper, which we know, has been linen, and undergone much workmanship, yet when well wetted and laid together in a heap, it will become exceedingly hot, so that, as my copperplate printer tells me, he can hardly bear his hand on it. As to *mineral* substances, many of them may be said to be greatly composed of fire; give them but access of water, and we shall presently behold a conflagration.

“Mr. Lemery, as far as I have been able to learn, was the first person who illustrated, by actual experiment, the origin of subterraneous fires. He mixed twenty five pounds of *powdered sulphur* with an equal weight of *iron filings*; and having kneaded the mixture together by means of a little *water*, into the consistence of a paste, he put it into an iron pot, covered it with a cloth and buried the whole, a foot under ground. In about eight or nine hours time the earth swelled, grew warm, and cracked; hot sulphureous vapours were perceived: a flame which dilated the cracks was observed; the superincumbent earth was covered with a yellow and black powder: in short, a subterraneous fire, producing a volcano in miniature, was spontaneously lighted up from the reciprocal actions of sulphur, iron, and water.”

“It has been observed, that large quantities of the materials are not requisite to make the experiment succeed, provided there be a due proportion of water: half a pound of steel filings, half a pound of flour of brimstone, and fourteen ounces of water, will, when well mixed, acquire heat enough to make the mass take fire.”

“We are told by good authority, that one Wilson at *Ealand* in *Yorkshire* about the year 1664, or before, had piled up in a

barn many cart loads of the pyrites, or brass lumps, as they were called by the colliers, [usually separated from coal,] for some secret purpose of his own: the roof of the barn happening to be bad, the pyrites were wetted by the rain: in this state they began to smoke, and presently *took fire*, and burned like red hot coals."

We have an account, in the Philosophical Transactions for 1693, of a covetous master of a copperas work at *Whitstable* in *Kent*, who in order to break his neighbour's work, had engrossed all the Pyrites or copperas-stone in the country: he built a shed over two or three hundred tons of these stones, to keep off the rain. In the space, however, of six or seven months, the mass (being probably wetted by the moisture of the atmosphere, or by the rain which, notwithstanding the shed, might have fallen upon it) *took fire*, and burned for a week; it quite destroyed his shed, and disappointed all his hopes of profit; for the pyrites was in part converted into a substance like melted metal, and in part it looked like red-hot stones: all the sulphur was consumed, and the neighbourhood was miserably afflicted by the noxious exhalation which it sent forth.

There are some sorts of earth from which allum is made, which abound so much with pyrites, that the proprietors of the works are forced to keep them constantly drenched in water, in order to prevent their taking fire.—But it would be useless to pursue this subject further; we have adduced proof sufficient, that nature furnishes materials, which may become the occasion of subterraneous fires. The requisite circumstances are—a proper quantity of the materials, a proper portion of water to moisten them, and perhaps a communication with the air. A small quantity of the pyrites is sufficient to kindle a fire; water is almost every where found in such great plenty below the surface of the earth, that it constitutes one of our greatest impediments to sinking pits of any great depth; and air, if it should be thought absolutely necessary to the spontaneous firing of the pyrites, may be conceived either to accompany the water in its dripping, or to descend into the innermost parts of the earth through the fissures which are found on its surface.

These instances of spontaneous fires arising from minerals, naturally remind us of the danger to which we are perpetually exposed by similar combinations. In fact, they often have occurred; vestiges of subterraneous fires are every where around us; they often are occurring, and I think I may venture to say, they would occur more frequently, were they not *restrained*. There seems therefore little occasion to doubt the possibility of that general conflagration of which we are forewarned; there are

so many predispositions toward it, that mere permission alone seems wanting to excite them to action. Some have supposed that deep in the earth fire has its principal residence; that there is the seat of this element; which from time to time dispatches its agents, and bursts open raging volcanos, spreading destruction over the labours of man, or raising islands from the bottom of the ocean, and compensating its ravages, by offering new settlements for habitation. But these are puny efforts, compared to what this element *can* perform; when the destined period arrives, when the dread commission is given, it shall burst the restraints which have so long controlled it, shall awake its fury, and shiver this terrestrial construction into ruin. Regardless of this beautiful frame of nature, its majesty and grandeur, its delicacy and finishing, its astonishing instances of omnipotent wisdom and power,—these it shall waste with devouring rapidity: who then will regret, that human productions perish in undistinguished destruction, that what had been the delights of the sons of men are consumed, that their pomp, their pride, their emulation, their magnificence, are all—all, annihilated by devouring FIRE?

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OF LIGHT, AND OTHER FLUIDS.

WE have treated on those principles, which, from their combination with, and their share in the formation of, all sensible objects on this terrestrial planet, are denominated ELEMENTS, *Air, Water, Earth, Fire*, whose influences are extensive, intimate, and indispensable; we trace with certainty their effects, and suffer no doubt of their powers, though many difficulties impede our knowledge of their modes of action, or the springs and movements, which, by their means, produce such effects as daily occur around us. It remains now, that we suggest a few remarks on principles no less interesting, though less frequently the subjects of our attention.

We have found reason to suppose, that of the four elements, three were fluids; and indeed fluids, by their mutability, seem well adapted for general distribution and use; as their equilibrium, or state of rest, is without difficulty disturbed, their

course is more easily directed, and when the impulse which actuates them ceases, they more readily return to that quiescent state which is natural to them. It must, however, be admitted, that by this very circumstance they are greatly concealed from our inspection, and our acquaintance with them is very much impeded, and very inadequate.

Beside the elementary fluids already mentioned, I wish to introduce a few words on that, which is usually termed the MAGNETIC *fluid*, because first indicated by its connection with the magnet, or loadstone, though now discovered to affect iron and steel universally, and to abound wherever we have carried our researches.

The natural magnet, or loadstone, is a kind of ore of iron, which has been in all ages famous for attracting pieces of iron at small distances, and by such attraction sustaining proportionate weights of that metal. THALES, amazed at so constant an effect, thought this stone *had a soul*. This most obvious property of the loadstone, of itself sufficiently embarrassing and inexplicable, is but the sign of a power infinitely more astonishing; in fact, this subject is a striking proof that nature has secrets, and that philosophy, if contented with present knowledge, foregoes most valuable and interesting discoveries, toward which, perhaps, the previous steps are already trodden. About the close of the eleventh, or beginning of the twelfth century, it was observed, that when the loadstone enjoyed free motion (as when swimming on a piece of cork in a basin of water), though its direction might be disturbed by the most rapid whirl, yet it would recover the position it had quitted; always pointing its same end to the North.

Experiment discovered, that the qualities of the magnet might be communicated from the natural ore to iron in general; and that when small bars of steel (called *needles*) were brought into contact with it, and properly rubbed upon it, they acquired these virtues in very considerable degrees. This operation was called *touching*; and hence originated the mariner's compass; an invention, by which the intercourse of mankind is inconceivably promoted, which, by giving scientific support to courage and skill, has done more at a stroke toward including all nations in one family, than all preceding ages, and all the endeavours of their philosophy or learning could accomplish. Is it asked, by what means we surround the globe? how we dare venture on unknown coasts, and how we discover our situation, wherever placed on the face of the earth? We answer these, and a thousand other questions of similar import, by a reference to the compass. If we speak of immense continents discovered—it

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was by the aid of the compass ; if we mention voyages from pole to pole—they are performed by direction of the compass : the life, the security, the perfection of navigation,—is the compass.

When the prodigious utility of the compass became generally known, nothing could be more natural, than to enquire on what principle this constancy of the needle depended, and whether iron might not be magnetic in other states beside that of ore. The result of such enquiries has been a conviction, that the principle of magnetism is generally distributed, and that iron either possesses or acquires it, long after it has been separated from the mineral, and wrought into household utensils. Scarce a poker, or pair of tongs, which are not constantly in use, but which (as in parlours) are suffered to remain in the same situation for at any time, but what is magnetic : out of every paper of sewing needles, many are magnetic. This is easily proved ; for if they be tried, some one will be found, which attracts and even raises up its neighbour, and sometimes one shall possess power to raise up several, hanging one below another.

An easy experiment acquaints us of the presence of magnetism : place a few needles very gently on the surface of a basin of water (where they will swim) and taking a needle, or poker, &c. gradually bring one end of it very near the floating needles ; a motion will soon be discovered among them, either of advancing or of recession, more or less considerable, according to circumstances.

Every bar of iron, or every needle, so far as it is magnetic, has an abiding inclination to point north and south ; and its ends are respectively denominated north and south *poles*. These poles possess an attractive, and a repulsive power : the north pole, for instance, draws to itself whatever of iron or steel is not beyond the limits of its attraction ; but if two magnetic needles be *opposed* to each other, so that the north pole of one be directed to the north pole of the other, a *repulse* will ensue, and they will mutually refuse to unite. This quality is accounted for, by supposing, that there exists in nature a fluid which has a peculiar attachment to iron (excluding other metals) and which *runs* along the magnetised needles, entering at the south pole, and *pouring off* at the north pole ; consequently the opposition of two *pourings-off* (as supposed above) must occasion a repellent force. This fluid is one of the most delicate we are acquainted with ; a magnet may be strengthened, if rubbed the *right way* for a considerable time, by another as weak as itself, and this continued will procure a very strong magnet : whereas, a few *rubblings* drawn the wrong way will totally spoil it. A few strokes of a hammer, under

der certain circumstances, will spoil a magnet, and in short, very trifles greatly affect magnetic needles.

We have in the *Philosophical Transactions*, an account of the *reversion* of the magnetism of a needle, so that the north pole of a compass on board a vessel, pointed south, after a thunder storm: to the no small surprize of the captain and people on board a ship in company, whose compass remained unaffected; who beheld with wonder their consort steering back to the West Indies, instead of continuing her course for England. So great an effect is rare; though small errors or variations of the compass, occasioned by thunder-storms, are not unusual.

When we speak of the *variation of the compass*, we understand a certain regular rotation, which in a series of years performs a revolution; for though we say a needle, properly touched, points a little to the east, or a little to the west; its *extremes* of declination are indeed a good deal to the east or to the west, exceeding twenty degrees in some places; for this variation is attended with these circumstances, (1) It is not the same two years together in the same place, but gradually maintains its progress eastward, or westward, according to which way it is going; till having reached its extreme, it gradually returns. (2.) The degree of variation is not the same all over the globe; but in some places, in the same latitude, it varies; as on the different sides of an island, isthmus, &c. (3.) Summer and winter have been thought to have some effect on this variation. (4.) Some persons think, that a very slight variation of this variation takes place, even in the course of a day, and that at midnight a needle does not point *precisely* where it pointed at noon.

The foregoing variation of the needle is always *horizontal*; but the needle has also another motion, whereby it seems as if its northern pole was the heaviest; so that this part of the instrument *dips*, as it is called, toward the earth, and the other part requires a counterpoise, to preserve a perfect equilibrium. This dipping varies also in various latitudes, and has been the subject of much ingenuity, though I believe of little practical advantage.

It would be easy to add much that might employ our time were I to introduce supposition and hypothesis;—I shall only hint, that some have thought the earth itself to be either one large magnet, or to contain a magnetic globe loose within it, whose poles varying from those of the earth, occasion a correspondent variation in the needle; but perhaps we may equally justly imagine, that the magnetic fluid is rather superficial, than deep in the earth, and is either furnished by the earth, or circulated over its surface, in continual streams and currents, not totally unlike the trade winds, though

in a contrary direction. How many other fluids may be circulating around us, we know not: I think there are indications of more than are usually suspected, and perhaps time may discover, that their influences are not inconsiderable.

As to the ELECTRIC fluid, I frankly own I am at a loss under what description to arrange it; whether as distinct from others, or whether as a peculiar modification of the element fire, which, brought into a smaller compass than it naturally occupies, has its customary effect upon light, and becomes visible by shining. I shall just remark of it, that its distribution is general, that its presence (as discovered by proper inductors) is perpetual, that it seems to be in constant motion, and fluctuation, scarce maintaining a state of rest, for an hour; that all objects have their share of it, that objects affect it from a distance, that when objects have too little of it, they attract a quantity from those which have too much, in order to maintain an equality; that it seems necessary to vitality, that it is capable of being collected in very large quantities, that then it may be made to perform most, if not all, the operations of common fire; and that, when collected in quantities beyond human ability, it is capable of irresistible effects; witness lightning, earthquakes, &c. How far these particulars agree with our idea of elementary fire, I submit to observation: only adding, that if it be so closely allied to one of the elements which enters into our composition, there is no occasion to wonder that, when medically used, it should produce surprising and beneficial effects, such as restoring feeling, &c. to limbs struck by the palsy, or other disorders. On this subject, I recollect an instance of a young man, who, by bathing when violently heated, lost his speech;—after many months of dumbness, while attending some electrical experiments, he accidentally received the shock of a very highly charged apparatus, which though it knocked him down, and deprived him of sense for the time, yet being taken care of, he recovered his health, and also the next day the use of his speech. When he was heated, did the cold water deprive him of that portion of electric fluid necessary to perform the functions, requisite to speech; which the apparatus afterwards restored?

The fluids we have hitherto noticed, seem appropriate to our globe; this seems to be their residence, their abode; we perceive them by their activity, their effects, their influences; and yet we find reason to suppose, that their nature is rather rest than activity: what then is that which excites them to motion? Is there one universal agent whose directions they obey, one prime (mechanical) cause which determines their course, which impels them

them to action by its presence, which if withdrawn, their action ceases? If there be such a general regulator, I think LIGHT seems to answer the character: a fluid inconceivably minute in its parts, astonishingly rapid in its progress, and of powers beyond comprehension: some of its properties we shall consider, as they appear to us; whether they will prove its universal agency, I do not determine.

We had occasion in our last discourse, to suggest various opinions in relation to the element fire: which by most philosophers has been (as appears to me,) too much confounded with light: one of these opinions supposed, that light was merely a particular motion propagated by vibrations, through a subtle æther. This idea had at one time many voices in its favour, and its similarity to the principles of sound seemed much to recommend it; but the properties of light with respect to colours, to inflection, and refraction, seem clearly to evince its being rather a material substance emitted from luminaries; which though it passes transparent mediums, is repelled or stifled, or absorbed in part, by opaque bodies.

We regard the sun as the source and principle of our light; perpetually distributing from its surface millions of particles extremely small, extremely elastic, and extremely rapid.

The particles of light are extremely *small*: to prove this, I shall not have recourse to calculation, or tell you they are less than the *twelve millionth part of a grain*, because the mind finds no less difficulty in conceiving such minuteness, than in conceiving of abstract terms; but I shall assume, that we see objects only by the light they reflect to our eyes. Let us fix this well in our minds; the rays of light rebounding from objects, enter our eyes, and there inform us of the presence of those objects; their forms, colours, magnitudes, &c. Let us instance this; in a room we behold the tables, the candles, the company, the ornaments in it, a multitude of particulars on either hand, a multitude of various colours and forms in very diversified combinations: All this we perceive at one single glance; that is to say, rays from every one of these objects, their divisions and subdivisions, enter without confusion into so small an aperture as the pupil of the eye. That we might distinguish the letters in a book held close to the eye, is supposable: but that we should equally well discern every fold in a dress, every stripe in a ribbon, and the very colours and forms of the figures in a drawing on the wainscot, implies wonderful fineness in those rays, which these minute objects transmit to the eye. If, in the day time, we advance to the window of a room, we receive rays from innumerable objects; ob-

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jects; we look down a long street, we survey every house, every passenger, and we read the very figures on the church clock at a distance.

Let imagination transport us to some lofty mountain's brow;—below are fruitful meadows, wherein we distinguish every tree and coppice, every house, almost every tile; we see the labourers at work, we see the course of a river, the country beyond it, miles after miles, till the sea closes the view, and just on the horizon up pops the mast of a vessel, with a flag upon it: these we distinguish with the naked eye: now apply to a telescope; we not only see the same things much stronger, but we also see many parts which are too small for distinct vision by the unassisted eye; but if we view them through the glass, we see the form of the flag, and even the cross upon it: from this cross then diverge rays of light, and these rays reach the glass, else we should not see the object. If we combine these particulars, we cannot but acknowledge the very amazing minuteness of those rays, which are able to paint all this within the dimensions of a quarter of an inch, or less: what then shall we say, when in reference to the moon, we reflect, that rays from an object two thousand miles in diameter enter the eye without confusion; or to the sun whose dimensions are millions; or to the heavens, which are inexpressibly extended; yet from their stellar fires—above—to the right—to the left, what prodigious streams of light reach, enter, and are transmitted into the eye! After this, I think we may justly forego any measurement of the particles of light, either by dimensions, or by weight; and yet I doubt not they have both, and both have perhaps very sensible effects upon us; the *wear out* our eyes. The light which falls perpetually on our eyes, in a course of years, perhaps abrades the retina, or corrodes it, even supposing they are not particularly exposed to its effects; but in some businesses which require very strong light, it is not uncommon to find their professors very early in life complain of the dimness of their sight.

I said also, that light is very *elastic*; that being thrown against any object, it rebounds like a ball from a wall, but with infinitely greater velocity: this appears from what we have been suggesting; whence come the rays which, when we are on a mountain's brow, shew us the trees, the coppice, the dwellings below? Whence come the rays which the distances direct to us? or those which render visible the vessel's mast, and its flag? Originally from the sun: the sun sends them to the earth with vigour; and from whatever they strike, they rebound to a very great distance.

I remember to have heard of a lady's observation, who standing on the White Tower in London, through a telescope could discern the sparkling of a pair of diamond buckles, worn at that time, in Greenwich park: that is to say, the solar beams which fell upon the diamonds, though refracted by them, and turned out of their course, yet were sufficiently elastic to rebound, so as to be sensible, through a glass, at three or four miles distance. How much farther they might reach, is difficult to say. Is this surprising? Let us recollect that the glister of windows from a house on a hill, in an evening, may be seen much farther: and what is this glister? it is but a very small portion of light; for by far the greater part which strikes those windows passes *through* them into the rooms of the house. Nobody in these rooms perceives any deficiency of light; but that trifling quantity which happens to be repulsed from the surface of the glass, spreads all around and becomes visible to the eye even in strong day-light, at many miles distance. How far may it travel ere its progress be totally subsided? Be it remembered, that when the eye does not perceive it a telescope will discover it, and a powerful telescope will notice it at a great distance. In fact, we may conceive that a very great number of rays thus reflected from equally small points, enable us to see the moon, and the planets: the satellites of Jupiter are indeed too remote to be seen by the naked eye, yet we are sure they send us light; for if not how could a telescope render them visible? The same we assert of those which surround Saturn, which are visible only by powerful glasses, and in a tranquil state of the air. I say, the light of the sun strikes them with velocity sufficient to rebound by its elasticity from them to us, though the distance be immense! Need I say more? need I appeal to the Georgian planet, to its satellites, at twenty times the distance of the sun from us? I rather think I may consider the assertion as demonstrated, and conclude that light is extremely elastic.

The *rapidity* and *velocity* of light seems, I think, to follow from what has been hinted; it is inconceivable that a slow-moving, heavy substance should be thus elastic; or that a particle, so very minute should *sleep* in its passage. On the contrary, a particle, an atom, thrown from a body so vast in bulk as the Sun, must needs quit that body with alacrity; and when by the rotatory motion of the Sun, its time is come to be whirled away, scarce the swiftness of thought can equal its rapidity.

The first demonstration of the passage of Light was gathered from eclipses of Jupiter's Satellites, after which many other proofs were discovered. That which is usually considered as the most surprising, is what has been observed of the fixed stars, whose light

is calculated to take up *six years* in coming to us, and yet is *ten thousand two hundred and ten times* swifter than the velocity of the earth in her orbit, moving *592 millions 180,000 miles* in an hour, or *one hundred and seventy thousand miles* in one second of time. It is well for us that light is so very small in its particles! for were it only one millionth part of a grain in weight, what mischief would it not occasion! wherever it fell, it would strike with the force of a grain weight falling an hundred yards, which, on the tender coats of the eye, would be very injurious; and what shall we say to this injury so perpetually repeated, as light is admitted into the eye.

Light always proceed in one direction; *i. e.* a right line from the luminary which emits it: this is easily proved by shadows, which are so many interceptions of light, whose forms always correspond to those of their original, and to lines drawn direct from the luminary. But though light naturally proceeds in strait lines, it is very susceptible of the attraction, as well of denser mediums, as of solid bodies. We have noticed the power of the atmosphere, in attracting and inflecting rays of light, which continually increase their inflection the nearer they approach the earth, because the medium is continually increasing in density: and this is considered as evidence that light is truly matter; since all matter is attracted by other matter, and feels its influence.

As a proof: we find by experience, that in proportion to the density of a body is its attractive effect upon light; hence the refracting angle of water differs from that of glass, and particular glasses differ from each other. There is no necessity for recurring to mathematical calculation in demonstrating these principles (though mathematics inform us more accurately of their powers and limits); whoever will hold a glass goblet, full of hot water between his eye and a lighted candle, will see that the rising vapour apparently moves the situation of the light a little from its true place; then let him elevate the goblet, till he looks through the water at the light, which will be considerably displaced; then emptying the goblet, looking at the light through the glass, raise it, lower it, move it on one side, then on the other, look through its solid stem; and it will appear, that the glass draws the rays of light so powerfully out of their course, that the real luminary, and that seen in the glass, are both visible at once, some inches distant from each other.

Light is by some bodies received, and admitted, indeed, but so superficially and circuitously, that it becomes stifled, blunted and deadened; whereas other bodies permit it to pass directly

through them, and these are transparent while the former are opaque. We may consider bodies in reference to transparency and opacity, as composed (1.) of similar and homogeneous particles, making one uniform medium of equal density throughout (such are water, glass, and diamonds), possessing equable disposition of particles, and of pores: light passes readily through these, because it suffers only one inflexion, in proportion to the density of the medium; to which having accommodated itself, it pursues the same course *through* the medium; which is thereby rendered transparent. (2.) But if a body be composed of various dissimilar and heterogeneous particles, such as metallic *laminae*, salts, earths, oils, water, &c. these being different in density, in disposition, in pores, &c. light is so twisted, twirled, and harassed in endeavouring to find a passage, that it is totally lost and absorbed; does not pass through the body, nor is reflected from its internal parts to the eye. Opacity then proceeds from the windings of light, and the sinuosity and meandrings of the pores of bodies, and from the irregular situation of their particles. Oil and water mixed are opaque, though transparent separately. Beer is transparent, but its bubbles are opaque. Dry paper is opaque; wet paper is transparent; because the water interposed between the particles of the paper fills its pores, and affords more direct passage to the rays of light. The most opaque bodies, as wood or marble, are transparent when thin, because they do not possess a sufficient number of disorderly pores, to prevent the light from passing in tolerable regularity. But the most transparent bodies (as glasses) do not transmit *all* the light which falls upon them, but a considerable loss of light happens, by reason of what recoils upon its striking the glass; and this is found to be an insuperable difficulty in constructing telescopes, which, requiring several magnifying glasses, lose a portion of light from each, till at length, if too many glasses be inserted, there scarce remains light enough to depict on the eye the objects viewed, but a kind of white cloud seems to veil them.

We have proved that the particles of light are extremely small; we have now to add, that they are nevertheless thought to be of different sizes; our reason for this is, they are found to be of different colours, for colours are certainly the offspring of light, and every ray of the sun being a *mixture* or union of several kinds of light, excites in our eyes sensations correspondent to the component parts of such mixture. It is easy to observe the various highly brilliant colours which succeed each other in a bubble blown from soap; they appear like so many real colours, but are undoubtedly separations of the rays of light which fall on the bubble,

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ble, into their primary principles. We observe the same colours in cut glasses of all kinds, and in drinking-glasses, when filled with water; see what colours they cast on a table cloth; see what colours appear in the stems of such glasses, in the light transmitted through their feet, &c.

Observe further the instances of *paste* pins, or buckles, of mother-of-pearl, and of several kinds of gems; what renders them so brilliant! whence such variety of beautiful colours? different in different stones of the same buckle: and why is the gleam of colour changed by the least motion? a proof the stone itself is of no particular colour. The answer is ready—the rays of light which fall on such a buckle, &c. are, by the refractive power of the *paste*, divided into their several original colours, which making different angles of refraction, exhibit that particular colour which corresponds to the angle at which the eye views it. The same principles account for the highly resplendent colours of the varying plumage in the necks of many birds.

The usual proof of this principle, is the separation of the rays in a glass prism; and this, because easily manageable, is familiar. We have nothing more to do, than to shut out all light from a room, except what is admitted through a small hole in a window-shutter; against this hole we place a glass prism, and let the rays which pass through it fall on a sheet of white paper at a convenient distance. We observe, that the image on the paper will not represent a hole of corresponding shape to that in the window shutter; but will be very much lengthened, and will contain various colours, in the following order: red, orange, yellow, green, blue, indigo, violet, or a kind of blackish purple. These are termed the seven *primary* colours; and of these all others are composed. These appear always in the same order, and never with various intervals. Here, then, we have a ray of light which we usually call *white*, separated into seven other colours, not one of which is white.

It is natural to ask whether we can re-combine them into whiteness? We answer, Yes; by using a proper lens to counteract the effects of the prism, we return the rays from their present situation, and conduct them to that spot where they would have fallen, had no prism intercepted them: here, reunited, they appear white. Is it asked, whether they will not be whiter if the red ray be omitted? we answer, No: the predominance of the blue will prevent it: If the blue be omitted? No; the red will strongly glare; the whole is necessary to produce perfect whiteness, and no improvement can be made, either by addition or by diminution. Neither is it possible to
change

change the colour of one of these separated rays ; for instance, the red rays, transmitted through green glass, will receive no tinge of green, but will on a white paper still depict a red ; or the blue ray, transmitted through a red glass, will still continue blue.

Is it inquired *why* the glass separates them ? (which returns to a question already hinted) we can give no other reason, than supposing these rays to consist of particles of various sizes, which are proportionately attracted by the glass : the smallest particle is most strongly attracted ; we therefore expect *that* to pass out of the glass at the *greatest* deviation from its natural course ; this answers to the *violet* colour ; or, particles of light of this size, affect our sight with a sensation which we express by the term *violet colour*. If we suppose a number of particles somewhat larger, they will less feel the attractive influence of the glass, and will be less diverged ; these shall be, if you please, the *yellow* : and another size yet larger, shall be the *red*. Red rays then will always be the nearest to their natural direction, and may be thought the strongest colour, while the weaker violet suffers most violence, and is most deflected from its course.

Perhaps this matter may be yet more simply stated, thus ; light consists of three kinds of rays, red, yellow, and blue (for the intermediate colours are mixtures), which either issue in union from the sun, or are so united in their passage to us, as to form one fluid when they arrive here ; this fluid contains, therefore, the principles of all colours, and is separable into all colours, by bodies properly adapted to reflect its various combinations. Black is the privation of colour ; we are not therefore to expect this as resulting from light. White is the union of all the primary colours, and the more complete their union, the more brilliant the white.

What say natural objects to this theory ? Observe the clouds, they refract, and reflect the sun's light ; observe in an evening, how their colours gradually change from the afternoon's whiteness to deep crimson, and how that gradually changes to violet, and to grey. Observe the atmosphere when the sun sets without a cloud ; when he is somewhat declined, examine the quarter of the heavens opposite to him, it is red ; and it fades to violet. Around the sun is yellow, over head is blue ; trace the progress of these colours where the sun sets ; from red to orange, to yellow, to *greenish* (this is usually but faint), to blue, to grey. The gradual introduction and succession of these colours at different angles from the setting sun, are not only pleasant to observe, but also demonstrate that these principles are found in nature.

But

But, the grand natural proof of these principles is the RAINBOW which is simply a various application of them on an enlarged scale. Adverting again to the instance of the paste buckles, we say, that correspondent to the angle of the beholder's eye, with any one of these stones, would be the colour it reflects to him. If we suppose, that a stone at a certain angle shews red, elevate this a little it shews orange, a little higher it shows yellow, then green, blue, and so on, at different elevations. Instead of these different elevations of one stone, suppose each colour were allotted a stone to itself; then have we the primary colours of the bow. We have only to change the supposed stones for real drops of water, and the same effect will follow. Whenever the sun's light strikes on falling drops of rain, it is by them refracted into the prismatic colours; and if a spectator be placed in a proper angle to view them, these refractions will indicate themselves by shewing various colours to his eye. The angle under which the *most* refrangible rays are seen, is 40 deg. 17 min. the angle under which the *least* refrangible rays are seen, is 42 deg. 2 min. and all the particles of water *within* those two angles will exhibit the prismatic colours, and constitute the interior bow. To account for the circular form of the bow, we have only to reflect, that this angle is permanent; and as well on either hand, as looking upwards, requires the same degrees: if, therefore, it maintain an equal angle on all sides, the *sweep* of this angle (and of the bow) must be circular. The bottom part of the bow follows the same law; and rain-bows, *completely* circles, were seen by those who on the top of highly elevated mountains, could see to the angle requisite, as well below as above: as was the fact with those gentlemen sent by the kings of France and Spain, to measure an equatorial degree. The sight must have been extremely curious; and yet, among such danger and difficulties, no one will envy it to those who saw it. When, however, without danger and difficulty, nature presents what is curious to the eye of observation it inspires a pleasure of which ignorance is incapable. I shall frankly own, that standing on the beach at Ramsgate, I was highly delighted with what is termed a SEA-BOW, *i. e.* the prismatic colours refracted from the spray of the waves. To produce this, the sea must run high enough to afford a good deal of dashing spray; and the sun must (as in a rain-bow) be behind the spectator. But as it seldom happens, that when the sea runs so high the sun shines out clear, these phenomena are rarely noticed. The principles of this bow are the same as those of the rain-bow; but as many bows are seen at once, each wave making one, the sight is extremely curious. I remarked one formed by the spray

so close as to sprinkle me (I do not grudge a sprinkling for the sight), that its colours were highly brilliant and lively, very sparkling, though momentary.

To account for the appearance of a kind of *second Rainbow* above the first, of fainter appearance, and of colours *reverse* from the former, remark, that though much of the light which falls upon a drop of rain be refracted and reflected, and passing to the spectator's eye, there exhibits the prismatic colours, yet other rays remain which, after being reflected are again refracted, and quitting the drop at another part, *there also* diverge into the primary colours; so that were a spectator properly placed with regard to these, they would to his eye depict a coloured bow. This double effect cannot be produced by the same drops to the same spectator, but proceeds from different ranges of drops at different elevations. It is natural to expect that the colours of those rays which have suffered most refractions should be weakest.

Lunar Rainbows follow the same principles; and differ only as being occasioned by weaker light, being seen in the night time, and by being pale, or perhaps exhibiting one or two colours only, *well*, and the others imperfectly.

Hitherto the spectator has been supposed *between* the luminary and the cloud; but when a cloud is between the spectator and the luminary, what follows? If the cloud be so dense as to preclude the passage of light, it is clear none of the effects of light can be expected; but if it be thin, light, and transparent, we look for a HALO, or circle tinged with colours, surrounding the luminary. These are usually seen at night, and are thought to be light refracted through the sides of congelations somewhat flattish in form, wherein the red predominates as the least refrangible colour, and the extremities have a tint of blue. Sometimes we see round the moon only a circle of white: commonly very large; this is always in hazy weather, and originates from light reflected by such vapours; being larger or smaller, as they are more or less elevated. Vapour confined in a glass goblet, when just forming drops, before it begins to run down the sides of the glass, if placed before a light, and looked through, will exhibit the rudiments of a halo. The infinity of combinations among the clouds in the atmosphere, prevent the frequency of these phenomena. The rays of light are also promiscuously blended; and do not emerge parallel from drops in such clouds to the spectators eye; if they did, we should see round the sun, through a raining cloud, much brighter rainbows than we now are acquainted with: and some of these may occasionally be seen in a standing water which reflects the sun's face seen through a thin cloud.

If light be a fluid so exceedingly minute, and so strongly affected by all sensible objects, striking here, rebounding there, and never resting, no wonder it visits every creek and corner. If we exclude it when direct, it will enter by reflection, from some obliquity, from some object, near or remote; and while this fluid and its effects are so necessary to human comfort, let us ever remember with gratitude this its important property. Custom has rendered a great quantity of light necessary, to us who enjoy it at liberty; but it has been found by those in close confinement, that a little light enables them to discern even diminutive objects. I remember hearing the story of a man, long imprisoned in the dungeon of the Chatelet, at Paris, whose eyes became gradually so habituated to his darksome abode, that he could see the rats and mice which ran around him to pick up his crumbs. We may therefore justly suspect, that we are never *totally* without light, even in the darkest night, or the most profound obscurity: perhaps as the earth imbibes and treasures up heat, so it may light; in some degree at least.

Other effects produced by the agency of light, occur to observation; they chiefly respect its colorific powers. Plants excluded from light lose their colours, and become of a dingy white; but if any opening be left whereat light may enter, they will uniformly incline towards it, and those leaves which nearest approach it will be green, while those at a distance are white. Plants, while sprouting, being concealed from the light by a covering of earth are white; but no sooner do the tender leaves appear above ground, than they become green. Light, therefore, or its effects, seems necessary to the maturity of plants; or at least to that of their colours. Certain apples are painted from green to red, by frequently drawing upon them (when on the tree) by a pencil of water, the figure proposed, the pencilled parts gradually become red. Painted pictures, precluded from light, fade and become tarnished. If the south aspect of a house be painted, it will keep its colour better than the north aspect; and very much better than an underground apartment having a north aspect.

Light is found under certain circumstances to have corrosive effects; but there seems to be much caution required in determining what effects are attributable to light itself, and what to other agents; whose activity it impels; and while light and fire have been so generally confounded, no wonder the performances of one have been attributed to the other; or effects, in which perhaps both are necessary, have been thought to be produced by one alone. It seems, that the lunar rays (which are certainly mere light) have the effect to putrefy fish; or at least greatly to hasten their

their putrefaction: and therefore, in southern climates, the fishermen very carefully hide their fish from the moon-shine, a few hours exposed to which would render them unsaleable; even in our own country flesh in barrels will not take salt, if exposed to the rays of the moon.

It is very probable, that many other effects arise from this active fluid: but we are compelled to recollect, that our acquaintance with it is of necessity imperfect. Sight is the only sense which judges of it, and sight has the reputation of being easily deceived. Take a specimen or two. The rainbow, says sight, exists in the cloud: No, says philosophy, the falling drops of the cloud only separate the rays of light, and these separate rays appear to you in the form of a bow. A candle in the dark has a splendid crown of rays attending it: No, they exist only in your apprehension, being produced by the impulse of light on the Retina. Stars twinkle: No, they are alternately hid and discovered by atoms floating in our atmosphere. In fact, it has been queried, Whether there be any such quality as colour really existing; whether the rays of light, separate or combined, direct or reflected from surfaces proper to such or such rays, do not merely excite in our minds, by peculiar effects on our sight, *ideas* of correspondent colours: inasmuch, that it may be said, the seat of colours is rather the eye as it affects the mind, than coloured light, or than coloured objects?

It is not easy to reason accurately, yet familiarly, on mental perceptions; nor is it always that analogy must be trusted as a guide; yet when it affords an opening, we accept with pleasure the labours of those who endeavour to trace it. The agency of light we have noticed in various instances: but its influences are probably yet more extensive. Light is the finest and most powerful of fluids, impelling the fire by the agency of the solar rays; the fire expands and agitates the air, hence the origin of winds. Fire also maintains the waters in fluidity, &c. Air, actuated by fire, affects the waters in the instances of storms, vapours, &c. Water, air, and fire, as excited by light, affect the earth, by imparting the principles of fertility;—it seems, therefore, as if we might safely consider light as the first cause, acting through various elementary mediums. Or state it thus: life is supported by the productions of the earth;—which productions are composed of earth, water, and air, each of which has been excited by fire, and fire is excited by light. All the elements are necessary to life; but they must have action communicated to them, for of themselves they are inert. Each is likewise necessary; take away earth, of what value were the impulses of air, water, and fire, without

without a subject? Take away water, what an arid desert were the globe? Take away air, how shall we breathe? Take away fire, behold a frozen world of ice! Take away their chief agent, behold darkness that may be felt; the fire ceases its office, air, water, earth, are equally consolidated, equally hardened, equally unfit to support inhabitants; the residence of horror and despair, brooding calamity, desolation, and woe.

When we advance beyond the boundaries of our habitation, we must modestly content ourselves with conjecture; in the spirit of which, I shall suggest a few hints. There can be no continued motion of any body, unless there be a continued impulse exerted upon it: If we suppose any cessation of impulse, the motion will cease. Likewise, though a large body requires proportionate impulse, yet if in itself it be quiescent, and the impulse upon it be all in one uniform direction, an agent apparently feeble may have great effects. These ideas I apply to the motion of the earth as a planet, by supposing that an unceasing flood of light circulates round the sun, carrying with it bodies it meets in its course. Does not light then quit the sun in straight lines, thereby driving a body *from* the sun? Perhaps not: not *perfectly* straight. I reason thus: the revolatory motion of the sun about his axis, seems designed to throw off his superficial particles of light: no particle thrown from a revolving body follows a perfectly straight course, witness the drops thrown from a mop when trundling ('tis a familiar comparison though a homely one), witness the drops from a water-wheel, and many other instances. We may then assume, that the particles of light from the sun fall somewhat *obliquely* on the planets: next we enquire, which way do the planets circulate? The answer is, the same way as the sun revolves; *i. e.* *coincident* with this supposed course of the rays of light; the planets and the light follow the same course. But some planets have others around them; what impels these? Reflected light from their primaries: the moon revolves round the earth in the same direction, as that of the light reflected from the earth, considered as a rotatory body.

I conclude then, that light acts in conjunction with gravity and attraction; but I do not think that light, or any other mechanical principle whatever, originally imparted this motion; but, that it *may* be the agent used by the Supreme Intelligence, to maintain those motions which his power and pleasure communicated.

It is clear, that by this train of reasoning, a vacuum is exploded from the solar system, for we suppose the progress of light to

be incessant. I think too, it is exploded from every part of the universe with which we are acquainted: for where shall we travel beyond the reach of light? Were our own sun withdrawn (as at night he may be said to be from us), streams of light from the stars are multiplied around us; and where shall we fly to avoid it? to the right? we advance toward some of those resplendent bodies; to the left? we advance toward others; from each of which light issues in every direction. It is true their united beams are too feeble to answer the purposes of human life; their *comparative* effects is small upon our earth; and therefore the sun is appointed for our use. This is the dignity, the glory of light, it is indispensable: to us? not to us only; throughout the universe. Wherever are creatures there must be light, if they may be comfortable; Hence our sun shines on us by day, hence our moon reflects his beams by night; hence remoter planets have many attendants; hence stars are distributed throughout the vast expanse. Are there existant beings? there is a luminary. The firmament is crowded with luminaries, because light is of universal enjoyment. This they bestow, this they circulate, and (probably) this they re-collect. Light maintains the intercourse between distant systems, flies incessant throughout space, diffuses numberless blessings in its progress; ever alert, prompt, and vigorous, is not this the universal agent, that, without which, to be deserved not the name of being!

This seems a proper station at which to pause and to take a retrospect of the subjects we have discussed. What contrivance and wisdom is employed to *fit up* our residence! what an amazing expence of power and skill; at once beneficial and elegant; replete with the necessaries and the pleasures of life; and offering for support or delight, all that we are capable of enjoying, all that may satisfy our wishes.

What wise oeconomy appears in the composition and distribution of that necessary element AIR! to which we are under so many obligations, as supporting life by respiration, as friendly *tempering* our circulating blood, as contributing to our enjoyments of seeing and of hearing, and indeed of all our senses. While vegetation is influenced by Air, and the supports of life are themselves supported by it, to deny our obligations to this element, were not only ingratitude, but folly.

Nor let the translucent wave whether murmuring in the humble water-course, or rolling in the magnificent river, let it not pass without our acknowledgments. With what heavier curse could a man curse his enemies, than to wish them deprived of this salutary element; overhead a burning sky; beneath the feet a parched sand?
around

around—a wide spread desert ; no shrub to relieve the weary eye, no verdure to vary the tiresome prospect, to suggest the *possibility* of refreshment, such is the aspect of a land without WATER ! forsaken of vegetables, forsaken of animals, wild, barren, dreary, desolate. O for a bubbling fountain, for a cool spring, whose salubrious draught may restore enervated vigour, and recall departing life ! Fountains and springs Nature offers in plenty, freely distributing this indispensable element, at once abundant and invaluable ; such is her liberality to the sons of men !

On the productions of EARTH we subsist ; we ourselves are among its productions ; and however endowed with reason or genius, with acuteness of thought or depth of understanding, we trace our origin from the dust, and acknowledge our composition is but clay. A reflection at once exalting and humiliating. Of *this*—Earth is capable ! Is this capacity attached to *earth* ? Has *earth* been animated, enlivened, ennobled, in the rank of Being ? Is this nobility, this life, this animation, combined merely with *earth* ! which shall soon return to its first principles, to its native insensibility : how amazing is this !

Equally necessary the services of FIRE, equally numerous, equally valuable, from which we receive many, many benefits, yet whose mode of action defies our strictest scrutiny, our acutest penetration : secluded from our detection by danger, and escaping from our acquaintance by tenuity.

Hail, holy LIGHT, offspring of heaven ! first born,
Or of th' Eternal co-eternal beam !

May we express thee unblamed ! since GOD is light,
And never but in unapproached light.

Dwelt from eternity ; dwelt then in thee,
Bright effluence of bright essence increate !

Whose fountain who shall tell ? before the sun,
Before the heavens thou wert——

So much the rather, thou CELESTIAL LIGHT,
Shine inward, and the mind through all her pow'rs
Irradiate ; there plant eyes, all mist from thence
Purge and disperse !

MILTON.

OBSER-

OBSERVATIONS ON THE PLATES.

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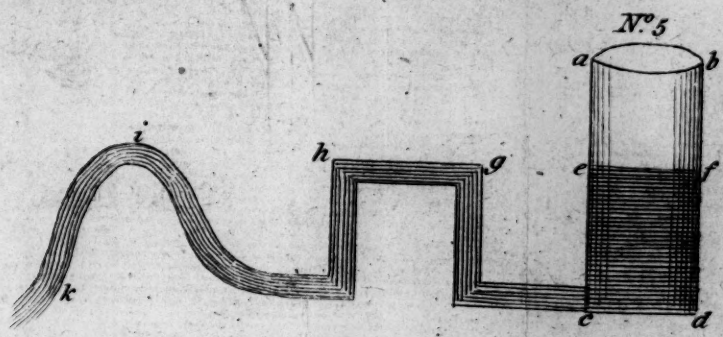
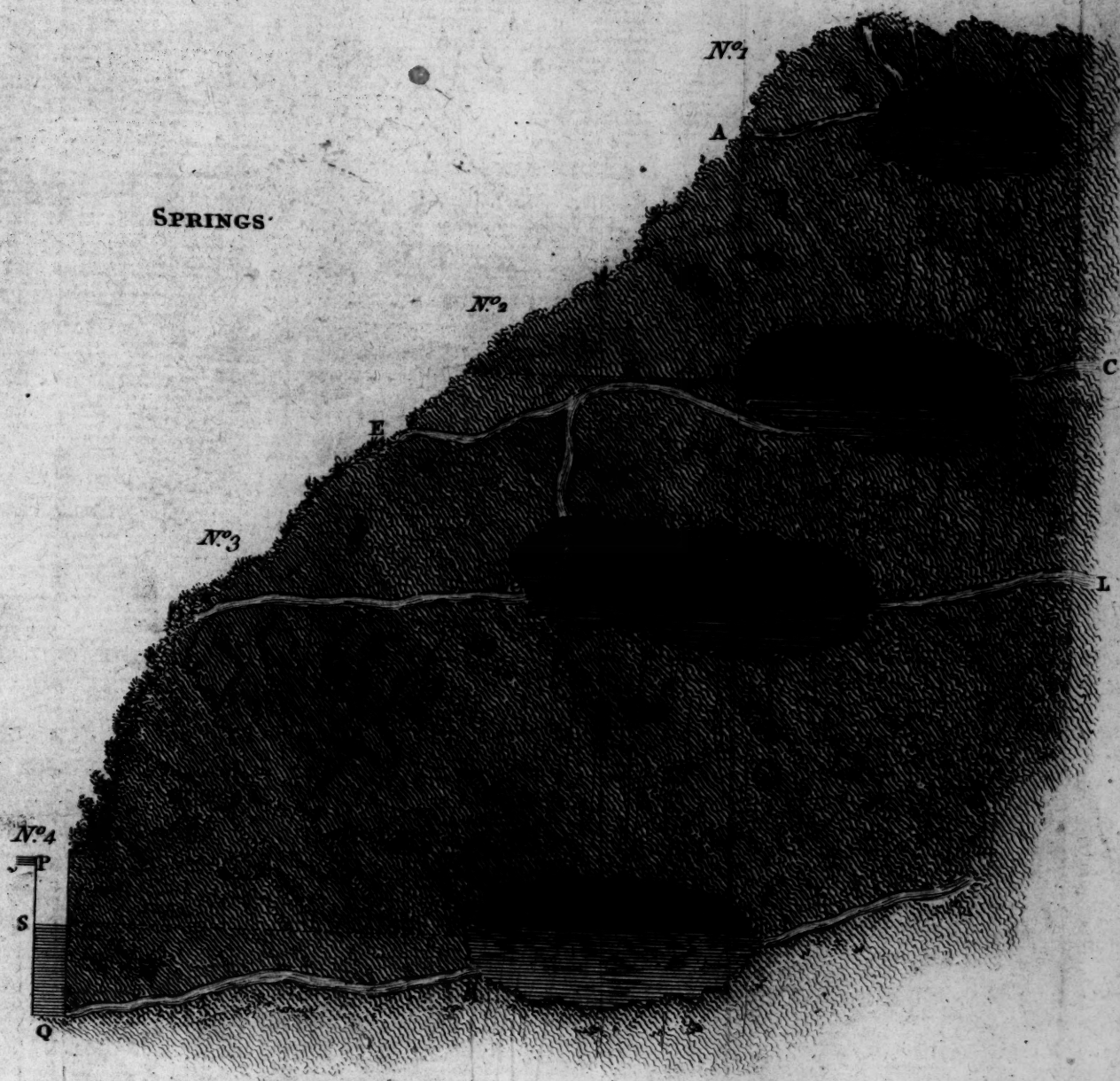
PLATE I. SPRINGS.

PLATE I. Represents the several sorts of SPRINGS, as they are usually divided into, (1) PERENNIAL, those which run continually; or (2) TEMPORARY, those which run only at times; (3) INTERMITTING SPRINGS, which flow and stop alternately; sometimes very frequently, and at small intervals; by regular intermissions. (4) RECIPROCATING SPRINGS, whose waters ebb and flow, by rising and falling alternately. These several kinds of springs are supposed to be situated in the same mountain or hill, and a section of the same exhibited to inspection.

No 1. The rains which have fallen on the hill's top, are supposed to have trickled through crevices, or channels, wherever they could find passage, till at length, settling in a basin, or collection of water, they are disposed to issue in a stream, and form a spring; it is evident, that so long as the water, in this basin rises so high as B, it will furnish the outlet A with a regular supply of water. and thus a spring may arise from the upper parts of any hill whatever: but if the reservoir be small, or the duct B. A. be large, this spring may fail, or at least be much diminished, unless it receives perpetual supplies from rains.

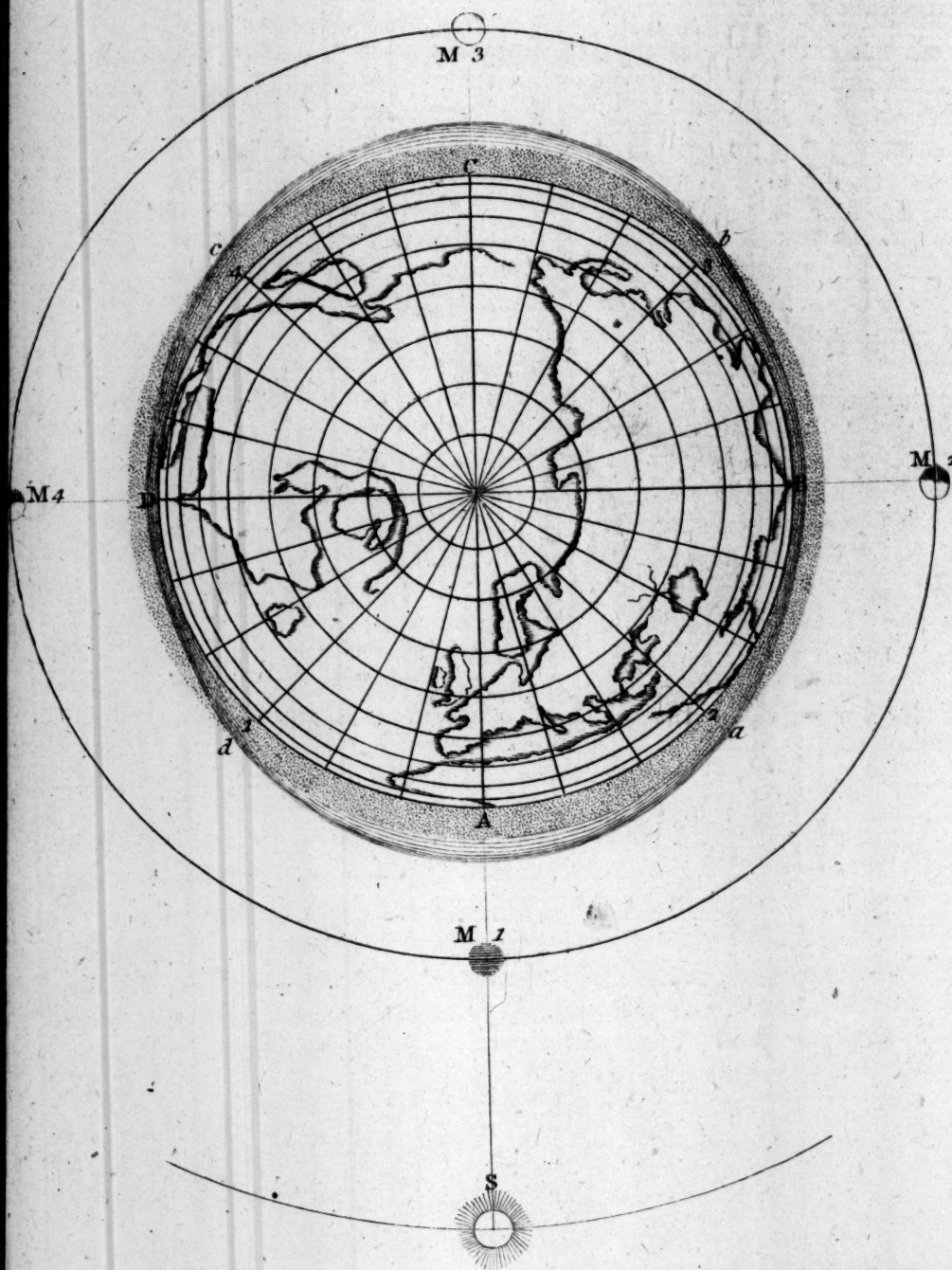
There is an odd phenomenon sometimes observed in such springs, *i. e.* they run in dry weather, and are dry in wet weather; which is easily solved, by observing, that during rain they are gathering waters, and that it requires some time for the water to rise so high as B, so that, probably, when the rain ceases, the reservoir being full, the water may issue by its channel B. A. and continue during the dry weather; but be exhausted again by the time of following rains. The same idea applies to Temporary Springs.

No. 2. Shews the principles of Intermitting Springs; which springs issue from a cavity where the water is collected, and which is continually receiving fresh supplies from some other sources, by the channel C. At H. on the lower part of the basin, is an outlet, H K E, which is of a curved form, rising at K: here it is evident, that only when the water arrives at the level D K, will it rise in the channel, high enough to run beyond K,





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K, and when it rises to that level, it will continue running through H to K, and so on to E, till it has drained the cavity dry: it will then cease, of course, till the water brought in by C, is again collected to the level D K.

No. 3. Reciprocating Springs, are formed by a combination of the foregoing; for if we suppose that beside its own inlet of water L, the stream of the basin, No. 2, instead of issuing at E, was added, as at M, it is clear that the spring O would run constantly by the supply of water from L, but would run with much greater force and plenty whenever it received the waters of the intermitting spring, by means of the conduit H K M; and its times of abundance would answer to the periods of the intermitting spring.

No. 4. Shews the principle on which water rises in wells, &c. which is always to that height, S, which is equal to the level of the water in the cavity:—the stream running from R to Q, and rising from Q to S, which is the utmost it will rise to, be the height of the well P what it may.

This property of water to rise in its level, and also, in some circumstances to empty itself, is explained by No. 5, where *a b c d* is supposed a vessel containing water to the level *e f*, from the bottom of this vessel issues a pipe of any form, as *g b i*: the water rising in this pipe to *g* and *h*, will there run over, and rise again to its original level *e f*, as at *i*; where it will again run over, and if the pipe *i k* be somewhat longer than the depth *c d e f*, the water will run out at *k*, and will not cease, till it has drawn the vessel *a b c d* dry to the very bottom. This principle affords an instrument very useful in drawing off many kinds of fluid commodities, called a *syphon*; if the syphon be inserted into the vessel *above* the bottom, it is evident it will draw off the upper parts of the fluid, and leave its sediment, feculencies, &c. undisturbed.

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PLATE TIDES.

THIS scheme illustrates the principles, We observe, first, that were the globe of the earth to be covered with water of any supposed depth, that water of itself would always maintain the same level, and form a ring round the globe, as *a b c d*. This would be little, if at all, sensibly changed, by any effect of the diurnal rotation of the earth; but some small effect would arise

arise from the attraction of the sun, S, which would constantly draw together those parts of the water adjacent to where it was vertical, as at A: and this rising of the water would follow its verticality in its daily course; but the immense distance of the object S, being so many millions of miles, would render this tide very trifling. But if a celestial body, as M, be supposed pretty near to the earth, the influence of such body must needs be very considerable.

M 1 is the moon in conjunction with the sun, consequently, the combined forces of these bodies, have now the greatest effect on the fluid element. Immediately beneath M 1, as at A, the waters appear assembled to the greatest depth, and gradually become shallower as we advance to *a*, which is the point of genuine depth of water; it being here neither elevated nor depressed. But as we proceed to B, we find the water becoming shallower, having lost so much of its quantity as the depth at A exceeds its just proportion. If we take the other side of A to *d*, and so on to D, we find the same occurrence, so that this entire hemisphere, D A B, feels the influence of the planet, and contributes, a greater or a lesser portion of the waters assembled at A. In the other hemisphere, B C D is an exact counterpart; for at the furthest possible distance from M 1, viz. C, the waters being lightest, are assembled, and here is high tide again: the points *b c* being the true uninfluenced depth, and B D low water.

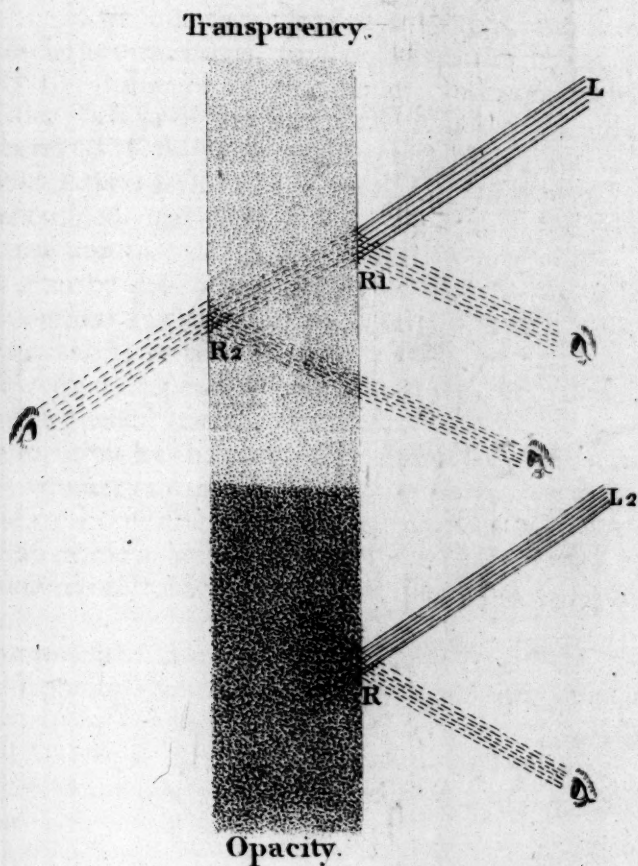
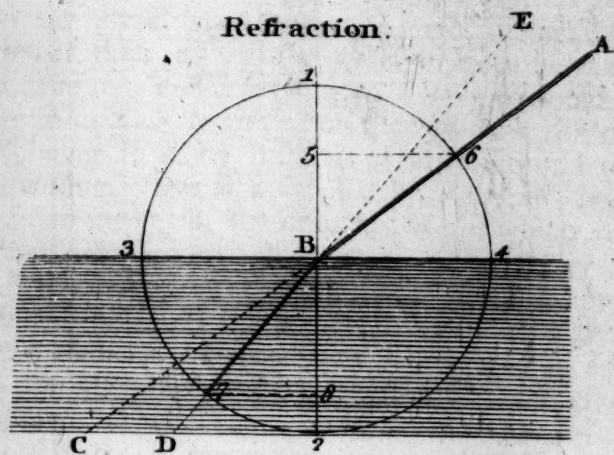
It is clear, that by the rotation of the earth, the object M 1 will constantly appear to change its situation; and also, that the depth of water, as A, immediately beneath it, will accompany it: and the corresponding depth, as C, will answer to that; always keeping the greatest possible distance.

It is clear also, that let the path of the moon be where it may, whether in the equator (as in this figure), or north, or south of the equator (as we know the moon varies from the ecliptic 5°), the water will assemble in north or south latitude, in perfect obedience to its lunar directress. These principles need no figure to illustrate them.

As the moon proceeds in her monthly course round the earth, she must, in advancing from M 1 gradually quit her conjunction with S, and take the station M 2, which is the first quarter: here the tides rise less than before, because the attraction of S, instead of adding to the power of M 2, counteracts it; drawing the waters from B toward *a* and A.

When the moon arrives at M 3, it is clear she attracts that part of the waters at C which are furthest from S, and are therefore less attracted by him; and which consequently are so much lighter





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lighter, and by so much more easily yielding to her impulse.— In the other hemisphere, the same occurs at A; these waters, of their own accord, would rise high, but this height is much augmented by the added impulse of S. Here we see the reason of higher (or *spring*) tides, at new and at full moon; as also of *neap*, or lower tides, in the quarters.

M 4, being merely a counterpart of M 2, is explained by that article.

The annual augmentation of the tides, as depending on those conjunctions of the sun and moon when, *ceteris paribus*, they have most power on the earth, is easily conceivable from these principles.

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PLATE III. REFRACTION.

THIS figure shews the attractive effect of different mediums on rays of light. If A B, be a ray supposed passing in the air in one uniform direction, when arrived near to the point B, it will feel the influence of the medium 3 B 4; and will be drawn by it out of the course it would follow (as A B C) were no such denser medium present; and will now be inclined toward the perpendicular (1 5 B 8 2), and describe the line B 7 D: varying its passage the distance between C and D. The reason of this is, that the force of the attraction of this medium (and of all others), being perpendicular to its surface, it draws the ray as near as it can to its own direction, *i. e.* towards the perpendicular.

If around B, as a centre, be described a circle, as 1 3 2 4, and where that circle cuts the incident ray A B, and the refracted ray B D, parallel lines be drawn to the perpendicular, as 5 6, and 7 8, the proportion of these lines to each other will inform us of the quantity and force of the different refractive powers of the two mediums. If the refraction be out of air into water, the line 7 8 will be to the line 5 6, as 3 to 4 (*i. e.* shorter by a quarter of its length). If out of air into glass, it will be as 11 to 17; or nearly as 2 to 3 (losing one third of its length). Into diamond greater still.

This figure may be reversed in its idea; and we may suppose the ray of light passing from a denser medium into a rarer; where, instead of being drawn toward the perpendicular, it is

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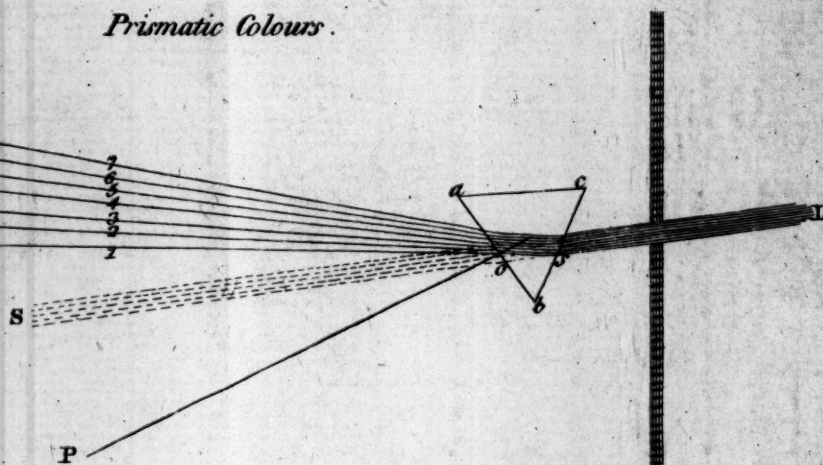
deflected toward the *horizon*; its first course being D B, its latter course B A; so that instead of going on to E, its passage is now varied the distance from E to A. It is clear that all circumstances are reversed from what they were before, and were any one desirous to look along the line B D (supposing it a stick for instance), he must not place his eye at E, but at A. It is clear also, that the part of such stick, which is beneath the water, will lose in appearance one quarter of its real length; such being the proportion of the line 7 8, to the line 5 6. We see also the reason why A not only sees to C (as in air he would do), but also much *deeper* into the fluid, as B 7 D.

TRANSPARENCY. In this figure, L is a pencil of rays striking a supposed surface, from which a portion of them is *reflected*, which renders this surface visible to an eye placed at a corresponding angle: this is the first reflection (R 1). But the remainder of these rays, having accommodated themselves to the direction imposed on them by the attractive power of this body, pass *through* it; and at its *further* surface are again divided, part passing into whatever medium may be behind the body, whereby the internal nature of the body becomes visible to an eye *beyond* it; and part forming a second reflection (R 2) whereby it renders the same visible to an eye *before* the body. The second reflection is always more considerable than the first.

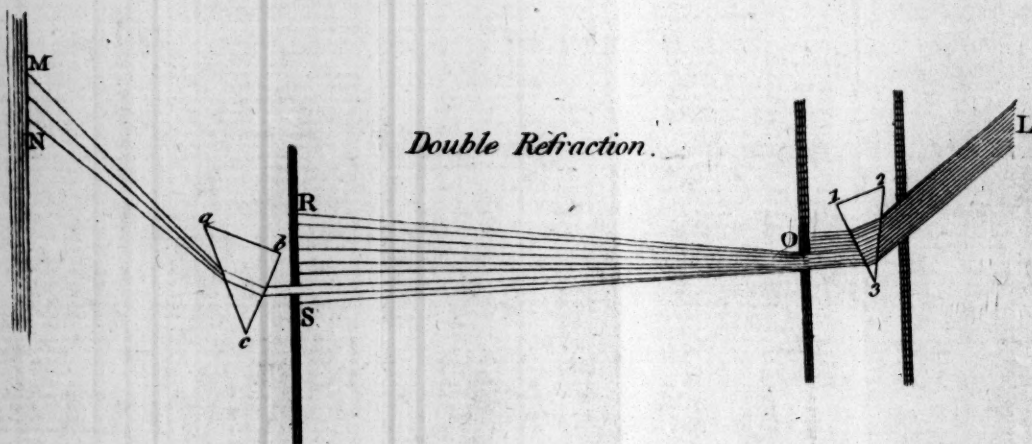
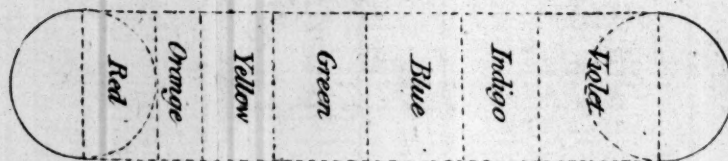
OPACITY. The pores in the former figure were supposed similar, uniform, and alike; so that having sustained one inflection, the light had no impediment to its further progress; but, in this figure, they are supposed to be irregular in their positions, their forms, their sizes, &c. So that after having accommodated itself to the pores at the surface of this body (as R), it has also to vary its course for a second set of pores;— then for a third, &c. till it is totally *stifled*, and disappointed, in its endeavours to find a passage.



Prismatic Colours.



Proportions of the Colours.



Double Refraction.

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PLATE IV. PRISMATIC COLOURS.

THOUGH a ray of light feels the attraction of a medium denser than that in which it is moving, yet as that ray is itself a mixture, some of its parts are influenced by such attraction more than others, as appears by this experiment: *L* is a pencil of rays passing through a hole in a window-shutter into a darkened room; where they are received on a prism *a, b, c*, falling on it at *s*. The superior density of this medium immediately reflects them from their true course (to *S*;) and they pass out at the further side of this medium in a state of separation, forming the coloured image, *R, O, Y, G, B, I, V*, on which we observe, that those particles of light which depict *R* the red, are *always nearest* to the perpendicular (*P*) of that side of the prism (*a, b*) from whence they issue, let the medium be what it may. Next to the red, are *O* the orange, then *Y* the yellow, *G* green, *B* blue, *I* indigo, and lastly *V* the violet.

This order is so constant, that were the letters away, and merely the figures 1 2 3 4 5 6 7, marked on the lines, any person conversant with the subject, would at once pronounce, that the ray 1 would be the red, the ray 2 the orange, 3 the yellow, and so on, according to their distance from the perpendicular (*P*).

The proportions of the Colours, are not all equal in regard of the space they occupy; but, as appears in this figure, the orange is but small, while the green, blue, and violet are large.

DOUBLE REFRACTION. This experiment is that by which Sir ISAAC NEWTON thought his doctrine of light and colours was absolutely demonstrated, and therefore he termed it *experimentum crucis*. *L* is a pencil of rays, passing as before through a hole in a window-shutter, and falling on a prism 1 2 3, whereby they are separated into their primary colours; near this prism place a board (as *O*) with a hole in it, so as to let only one kind of ray pass through it at one time; this ray will in consequence be prolonged from *O* to an opposite part of the room, as *R* and *S*. If in *R S* be made a perforation, so as to admit but a small part of the coloured ray, that part will be received on a prism behind *R S* (as *a b c*). If the first prism (1 2 3) be turned on its axis, in the order of the figures, it is clear that each ray in its order will pass through *O* to *R S*; and through this perforation also, to the second prism *a b c*. By this

this prism each will be refracted (as entering a denser medium than that it quits), and this refraction will be, as before, less influential on the red rays than on the others; so that whereas the violet will rise to M, the red will only rise to N; the intermediate colours, being intermediate still, exactly as before. Which seems to prove, that if these rays, when separated, are yet affected by the attraction of the glass in various proportions of force, they have certain *essential* and *constant* differences between themselves: of which a difference in size, and perhaps also in density, seems to be ascertained by the principles of attraction. As all the rays maintain their several colours, and though a second time refracted, yet continue red, orange, &c. no further change in their properties, as light, is to be expected.

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PLATE V. RAINBOW.

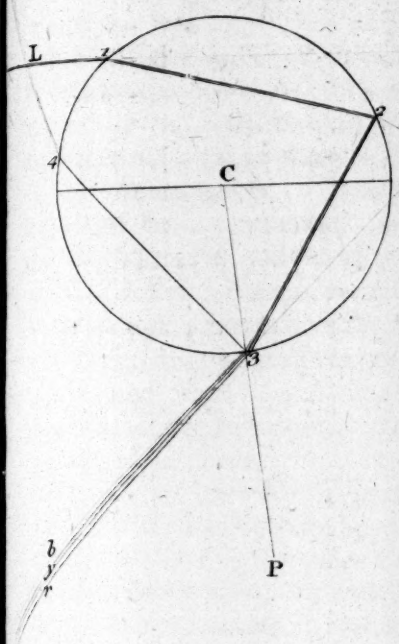
WE have already stated, that a ray of light, passing out of air into water, will be attracted by the water as a denser medium, and deflected from its course (Plate I. fig. 1), also,—that from the further side of a transparent body is by much the most considerable reflection of light (Plate I. *Transparency*, R 2); also,—that a ray of light passing through certain mediums, is, at its exit into a rarer medium, diverged into its primary colours (Plate IV. *Prismatic Colours*). We have now to combine these three principles, in order to account for the generation of a RAINBOW: which is merely a natural instance of prismatic separation of colours.

No. 1. L is a ray of light, which striking on a spherical drop of falling rain, instead of continuing its course to O, is by the attraction of the drop, as a denser medium, inflected to 2, where some of it passes out; but the remainder is reflected from 2 to 3, from whence it issues, separated into its component colours. Now, in order to know which colour we are to expect in any supposed point, we are to recollect, that the *nearest* to be perpendicular (C 3 P) is red, and the *furthest* is violet; these form the RAINBOW.—[To avoid confusion on the plate, the letters *r y b* only are used, signifying *red, yellow, and blue*;]—since, if these issue right, the intermediate colours must follow of course. But though much of the light be lost by its exit at 3, yet there remain

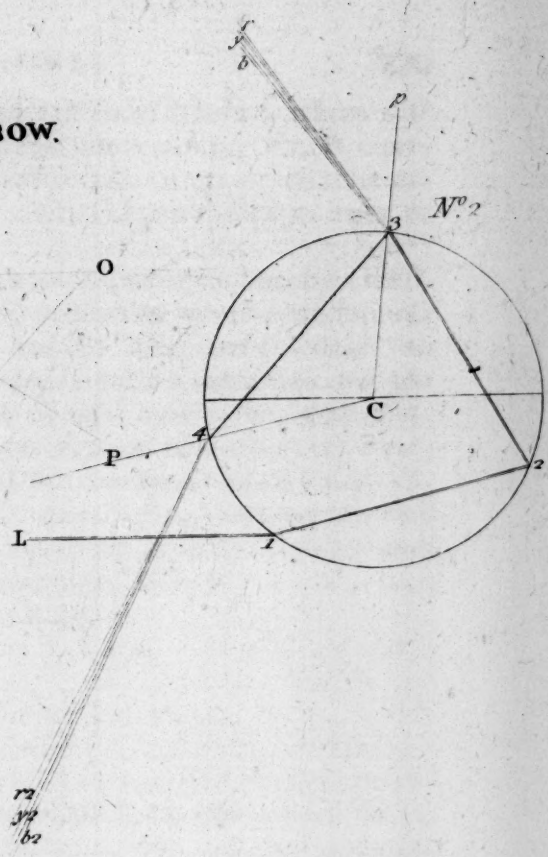


RAINBOW.

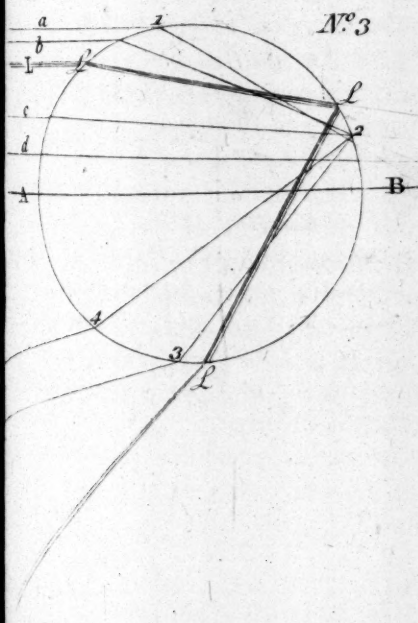
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remains enough to be further reflected from 3 to 4; where it is again refracted, and issues in separate colours. It is clear, that were a spectator situated *above* this drop, *these* colours would to his eye appear distinct. These form the upper bow, or WATER-GALL.

No. 2. shews the effect just hinted, in a drop as seen by a spectator situated *below* it. In order to describe which, we suppose the ray of light which enters toward the *bottom* of the drop, to be that we design to trace; because, the different situation of the spectator requires it. *L* is a ray of light striking the drop at 1, refracted to 2, reflected to 3, where most of it issues in its primary colours (*r y b*); that nearest the perpendicular (*C 3 p*), as usual is red; but the remainder of this light, is from 3 reflected to 4, where it issues in a state of separation as to its colours; and, as before, that nearest the perpendicular (*C 4 P*) is red; then yellow, and then *bl e* (*r 2, y 2, b 2*).

It is natural to suppose, that the rays *r 2, y 2, b 2*, are much weaker than those which have not been so often refracted and reflected, or have lost so great proportion of their light: which remark accounts for the apparent weakness and indistinct faintness always noticed in the upper bow. The *reverse* order of the colours is clearly seen, by comparing these two figures. In No. 1, the rainbow refraction reads, *b, y, r*; in No. 2, the water-gall refraction reads, *r 2, y 2, b 2*; *reverse* from the former.

No. 3. explains the reason why only those rays which fall *in* or *near* the direction *L*, are concerned in producing the colours. By tracing the ray *L*, *L* to *L*, it appears to strike the further side of the drop at the *greatest* possible distance from its axis *A B* *above* its axis; and to be *reflected* to the *nearest* possible distance *below* its axis: so that the whole pencil of rays is kept compact, and assembled together as much as may be, thereby preserving force sufficient to depict the colours. Whereas all other rays above or below *L*, are so separated and thinned at their exit from the drop, that they are scattered and lost, and become too weak to produce colour. The former are termed *efficacious rays* the latter *inefficacious rays*. Trace, as an instance, the ray *a* to 1, to 2, to 3, where it comes out alone; for though the ray *b* strikes the drop originally not far from *a* yet after its refractions, &c. it comes out nearly at 4, which is too far from 3 to produce any effect. The same reasoning applies to the lower rays *c, d*.

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PLATE VI. RAINBOW.

AS it is evidently impossible, by reason of the divergence of the rays, that any single drop should exhibit at the same time *all* the RAIN-BOW colours to the eye of a spectator, in this example we suppose several drops, or ranges of drops, one *above* another; and it appears that, as the drops at different heights present different colours, all the colours are presented by means of each range furnishing *that* proper to those of its rays which strike a spectator's eye.

L L are rays of light, striking the drops nearly at the top; these being refracted are reflected, and come out diverged: that nearest the perpendicular drawn from the center of the drop, is red (R), which, of all that issue from this drop, alone can strike the eye of the spectator; the others being dispersed *around* the eye (as o, y, g, b, i, v.), but not reaching it. The second drop is so situated, that not its ray nearest to the perpendicular, but than *next* to it, reaches the spectator's eye; all the others being lost: this depicts the orange (O). The yellow (Y) rays are next above that, all others from this drop being invisible; the green (G) is the center ray; the blue (B) is the upper ray but two; the indigo (I) the upper but one; and the violet (V), as most refracted, is that ray *farthest* from the perpendicular drawn from the center of the drop; all the other rays of this drop falling *below* the eye (as i, b, g, y, o, v.); consequently they are inefficacious. After consideration of the foregoing plates, especially No. 1, Plate V. this figure needs no further explanation.

A is a ray of light parallel to L L, passing through the eye of a spectator; and thereby becoming the axis from which the angular bearings of the refractions, &c. are to be calculated: the lower angle A V, being 40 deg. 17 min.; the upper angle A R, being 42 deg. 2 min.

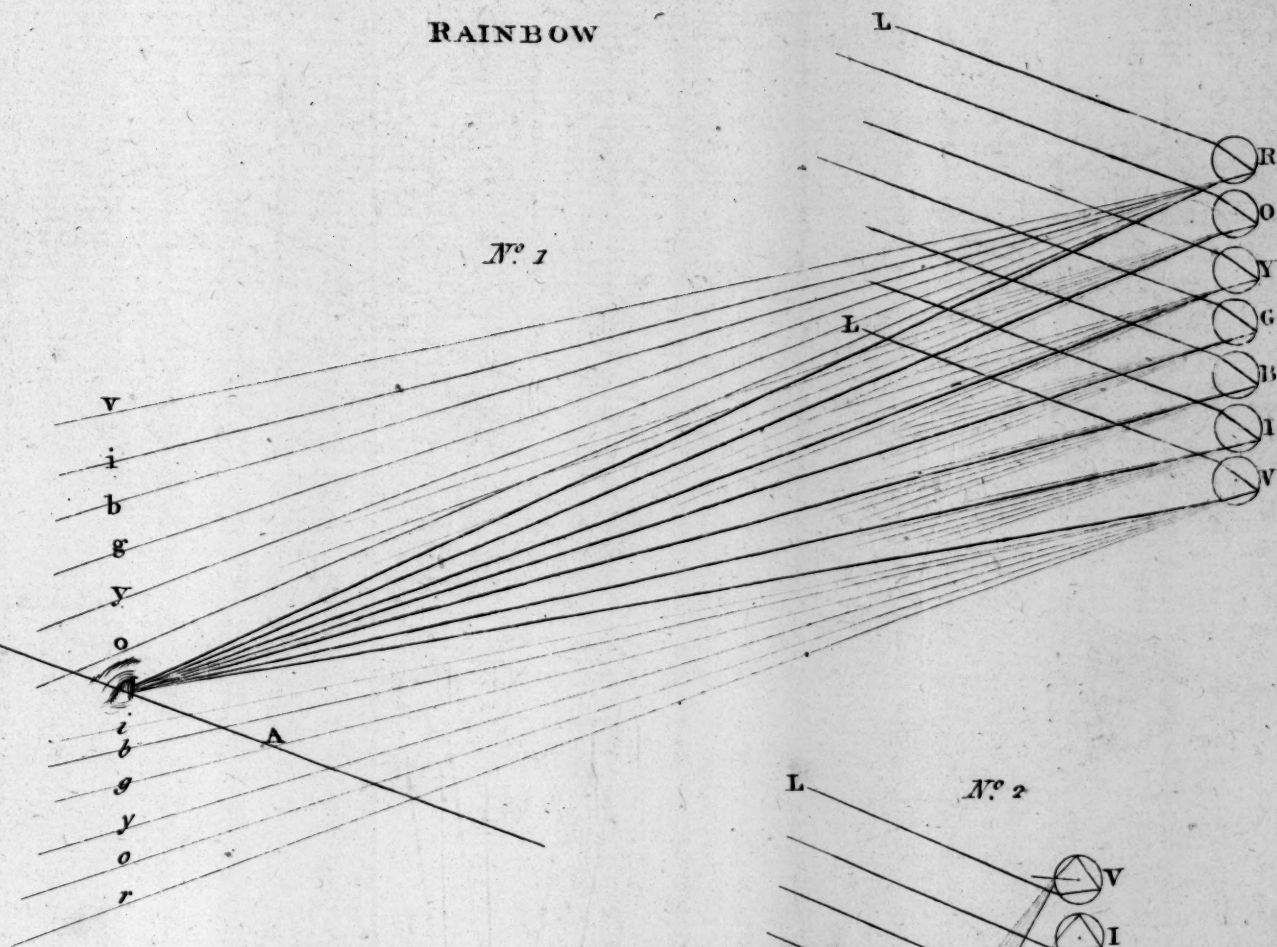
No. 2, is a similar representation of the colours of the *water-gall*: but the colours are contrary in their order. The drop which appears red (R) being now *lowest*, the orange *above* that, and so on, till the violet takes the upper place among the drops.

It is evident that by the same process as in No. 1, the *under* ray of the *upper* drop is violet; the next above it indigo; and so on, till the *upper* ray of the *lowest* drop is red. L L are rays of light as before.

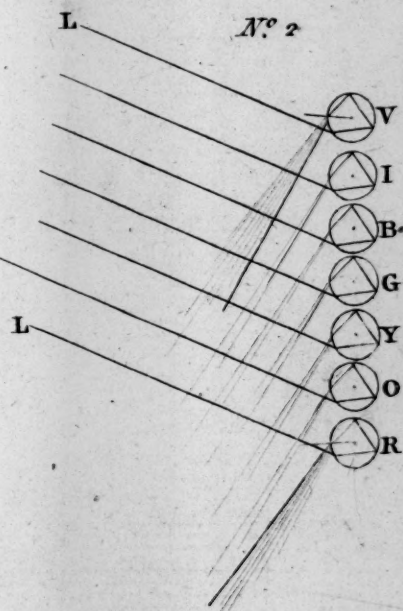
THE

RAINBOW

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London. Published by C. Taylor Holborn. Decr 1795.

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P A R T II.

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W HATEVER be the occurrences around us, or by whatever principles our animal frame may be actuated, the modes under which we receive information concerning them, are reduced to a few simple and regular operations, which we term SENSES; by these we feel, or see, or hear, or smell, or taste; what knowledge we acquire, is by one or other of these mediums, and these are sufficient for the purposes of human life.

I have heard it suggested, that possibly animals have other senses whose office may be to direct their choice of food, and other selections, necessary to comfortable subsistence; to guide that principle which we call instinct, and to determine by summary process, between advantageous and detrimental. This idea seems to me erroneous, as superior degrees of these very senses we have mentioned are capable of accomplishing every requisite purpose; nevertheless, that there may be superior orders of beings, whose more numerous, and more extensive faculties render ours but trivial in comparison, is beyond denial; but these we are not called

called to investigate, till we have cultivated our own to that perfection of which they are capable.

That sense which is most generally diffused, which is most exact, which is most spread in the individual, and is most freely bestowed to every rank of creatures, is *FEELING*. There are some which (seemingly) possess this only; but there are none possessing others, yet destitute of this.

How far subjects of the vegetable kingdom may possess senses, of any kind we know not; we discern no provision made for their exercise; but if such provision may be made, it relates in all probability to the sense of feeling. The advances toward the exercise of feeling which are exhibited by vegetables, appear in their flowers, some of which, if touched within their petals by a fine needle, at the time when their farina is ripe, will transmit the *impression* to the stamina (on which the farina resides), and cause them to shed it. We are ignorant by what mechanism this is performed; it seems to be the height of vegetable sensation, and contributes to strengthen the idea, that whatever is related to life is the object of nature's especial care, and highest contrivance.

Poets have, with their accustomed license, used the phrases "all eye, all ear:" the expression "all feeling" is, I believe, coming nearer to fact. Nay, perhaps all our senses are strongly related to feeling, and are but more delicate degrees of this quality, varied and diversified.

The ideas we have to suggest on the sense of feeling, include, (1.) Its liberal donation throughout all ranks of creatures. (2.) Its general distribution in the individual. (3.) Its accuracy; and to these we must add, (4.) The mode of its action. A few words on each of these may furnish agreeable instruction.

All ranks of creatures possess the sense of feeling, but not all alike, or in equal degrees. Fish I conceive have the smallest share, also cold-blooded animals in general. When we consider the dense and cold fluid in which fish reside, its increasing coldness and density at considerable depths, we may perhaps with little risk, regard these creatures as void of delicate feelings; since otherwise, the sudden changes which some of them are perpetually experiencing must be extremely injurious. I am not ignorant that some kinds of fish (whales, &c.) are of warm blood; but, beside that these breathe like land animals, they have also prodigious defences of fat surrounding them; by its thickness *keeping in* their own bodily heat, and *keeping out* the cold of the circumjacent waters; they are not therefore true fish, but of equivocal character. The rapidity of fish is great; it is scarcely

hyperbolical

hyperbolical to suppose, that one (a shark for instance) may to-day be deep beneath the ice in the coldest of waters; to-morrow, or next day, may sport on the superficial waves of the Tropical ocean. Such sudden changes would destroy a land animal, yet they seems to affect fish with no inconvenience. Whales, porpoises, dolphins, &c. fish of warm blood, have superior degrees of feeling; yet the fat of a whale is so insensible, that if a harpoon strike no deeper, the creature scarce winces; and not till the weapon penetrates the flesh, does he shew signs of considerable sensation.

Cold blooded land animals agree with fish in having little sense of injuries. We have hinted at some which regard the loss of a limb as a trifle, and which, if a fracture happen at an inconvenient part, themselves break off the remainder to a proper spot from whence to reproduce the member. Of this number are certain kinds of lizards, and I believe not a few insects.

Quadrupeds have this sense in superior degrees, yet if we may reason from appearances, the thickness of their hides, and their additional coat of hair, not a little blunts its exercise. There are some which no blows can move; as there are others (I do not speak it with pleasure) which receive so many blows, one would hope they had a smaller portion of feeling than we have reason to allow them; or at least, that beating would harden their skins to insensibility.

Superior degrees of feeling may be expected, where the medium between the sense and the subject is thinnest, and least refractory, and the union closest. This supposes, that the means of sensation are of equal powers; but that some may be superior to others in quality, as well as in number, cannot be doubted.

We proceed to notice the general distribution of this sense throughout the individual. If we instance ourselves, where shall we deny its presence? From the head to the foot this sense abounds; hence we become in every part susceptible of pleasure, of pain, of heat, of cold, of wet or dry, of whatever is rough or smooth, sharp or blunt. The sensation affects us every where, and every where alike; it is not here rough and there smooth, though some parts of us are less sensible of roughness and smoothness than others.

In general we say, feeling accompanies the skin; yet let us remember, that the outermost skin is void of feeling. We sometimes scratch it without perceiving the wound, and we sometimes raise it with a pen-knife, without injury. This becomes of great thickness by being hardy used; hence the hands of sailors, of rustics, or others engaged in laborious occupations, lose all delicacy

delicacy of feeling; hence the soles of the feet of those who walk much, are less tender than of those who ride; and if we did not accustom ourselves to shoes, the sole of the foot would become insensible to the stones of the street, or the gravel of the road. The inner skin is the seat of feeling.

There are other parts of us which have little feeling, as the nails, the hair, the bones, &c. Reasoning by analogy, we may conceive of creatures as possessing this sense very generally, yet having those parts most liable to injury, void of it; as the hoofs of quadrupeds, the shells of the crustaceous tribes, and generally all natural weapons.

The accuracy of feeling is beyond the conception of those who have not somewhat attended to it. The most observable seat of this sense, is the palm of the hand; other parts may receive or communicate a leading, or gross idea, may determine of general heat and cold, &c.; but the hand not only judges of these with more exactness, but also of forms, of weight, of motion, with minute accuracy. In determining of forms, the hand not only distinguishes round or square, a plane or a globe, but their compound figures. This is evident in the delicacy of feeling acquired by various artists in handling their tools: where a person unused to the business shall perceive no difference, the artist himself shall find, one and another tool does not suit his hand, or his purpose. The hand too, judges very accurately of what resistance it meets with, and proportion its exertion of strength, as wanted. In writing or drawing, or fingering of musical instruments, to what surprising delicacy of touch some persons have attained! To what accuracy an excellent player on the violin adjusts the pressure of his finger on a string! Not that he sees where he places it, but by habit, his feeling accomplishes his purpose. That linen and woollen, and cotton manufacture, should feel different, is little wonder: but I remember to have read of a person who distinguished blindfold between silks of the same nature from different manufactories, though their apparent texture was alike. On the same principle, perhaps, do some blind men feel colours. The late Mr. STANLEY, the organist, who was blind, would often lay his hand on the shoulder of a friend, and tell him the colour of his coat; or surprise one by saying, "why do you wear scarlet? who are you in mourning for? or, what a lively brown you have on to-day." This can only be accounted for, by supposing, that the dyes of these colours were composed of ingredients, which did not feel alike to a touch so delicate. Somewhat the same is reported of Professor SAUNDERSON: and especially, that

that he once distinguished between a series of forged antique medals and the genuine ones, by the sagacity of his touch, though all had passed for genuine on a celebrated antiquary. He could also tell, when walking in a garden, whether he approached a tree, or other object, though there was no air perceptible to any other person of the company. Nor is this all which the sense of feeling has been known to do ; for we have authentic accounts of an artist, who, though totally blind, could model perfect likenesses : he modelled the Grand Duke of Tuscany, being purposely kept in the dark : and the likeness was extraordinary. It being objected, that the Duke's beard contributed a peculiarity to the likeness, he modelled one of the Duchess's maids of honour, with equal success. His portrait yet exists, and the painter of it has marked his happy talent, by placing an eye at the end of each finger.

After these relations, little need be added to prove the precision of the sense of feeling. Some disorders, however, seem to aggravate its powers so greatly, that what sensations would be pleasant in health, now become excessively acute.

It is natural to inquire into the mode of action of a sense which we find so various and comprehensive, yet so minute and susceptible.

From the medullary substance of the brain (and the spinal marrow) issue a vast number of whitish fibres, slightly connected at first, afterwards somewhat more, yet still loosely ; but gradually becoming white, firm, and strong, like so many threads running together, and distributed over the whole frame ; these are the *nerves*, in their courses, they generally proceed a shorter way than the blood vessels, branching off at very acute angles. These form in some places a kind of knotty bodies, called *ganglions*. Whether these threads are solid or hollow, is debated, and perhaps will continue to be debated, as the extreme fineness of their ultimate divisions precludes our intimate acquaintance with them. In general, the idea of a fluid prevails ; and it seems to me most natural, since the existence and agency of many fluids formerly unknown, is now freely acknowledged, and since fluids seem capable of motion sufficiently active and impulsive, to produce any effect whatever. With regard to fineness of parts, to rapidity, and to power, the electric fluid is an instance, and seems somewhat allied to the nervous fluid, by its universality, its perpetual fluctuation, and its capacity of being augmented by very sudden causes.

But though the existence of this fluid should be granted, how it affects the sensorium, or how it is itself affected, is obscure ;

all we know is, the nerves are the medium of such sensations, that while the nerves are gently impressed without violence, the sensation is pleasant and agreeable ; beyond this, advances toward pain ; and disunion of the nerves, or of their parts, produces actual pain. That the nerves are also the cause of motion seems likely, because if a branch of them be injured, motion is injured also: for instance, if those passing over the shoulder and descending the arm be cut, the arm becomes useless wherever their branches extend, notwithstanding the seeming good disposition of the muscles. So if disease occur to the nerves in their more early stages, the whole side of the body where they extend becomes paralytic, and void of every degree of feeling.

The nerves generally proceed by pairs : Those principally occupied in the senses, proceed from the brain, which yields ten pair ; others from the spine, which yields thirty pair, distributed throughout the lower parts of the body. The spinal marrow is properly a prolongation of part of the brain, and is of the same nature and constituent parts. It is probable, that the nerves are thousands in number ; and to each part of the body is sent a distinct nerve ; not that several smaller unite into one larger (like brooks forming a river), but that each runs distinct from its termination on the skin, &c. &c. to the brain ; yet the whole, if united, would hardly make a cord of one inch in thickness. This is extremely wonderful, but is supported by numerous microscopical discoveries, whose analogy may justify the idea.

There is a strange kind of feeling which occurs, after a member, the seat of such feeling, is lost ; as after a man has had his leg cut off, he still conceives he feels pain in his toe. Many a Chelsea pensioner conceives he feels pain (the cold of winter, or the hardships of a march) in his leg, which perhaps he left in America. This may be accounted for by supposing, that the nerve which used to furnish such information is only taken away in part ; I say, that only its lower extremity is lost, and that part which is left feeling a similar sensation, the sensorium is influenced by the habit which it had acquired, and for a long time supposes the same effect to proceed from the same cause.

It is not so easy to account for the continuance of life and action in some creatures, after they are deprived of their heads the residence of the sensorium, and the origination of the nerves. It is well known that insects will run about in that condition, and a tortoise lived and moved months after it had lost its brains, and many days after having lost its head. I can find no means of accounting for this, but by supposing, that the *ganglions* furnished

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furnished the necessary supply of vitality, and that life was capable of prolongation till they were exhausted of their stores.

Of all the senses, feeling is least liable to be deceived: it is not a sense which can act at a distance, or receive ideas from afar; its powers are circumscribed to a narrow compass, but within that compass they are generally just, and transmit determinate and forcible ideas. Prepossession, indeed, many sometimes deceive this sense; where we expect to find a thing, we are ready to think we feel it, though it be absent. Many a person next door to a house on fire, or supposed to be on fire, has thought he felt the wall hot (I have an instance in my thoughts). On the contrary, we have authentic accounts which represent martyrs as free from the sufferings their enemies intended to inflict.

We have considered the hand as the chief seat of feeling in the human species; its form is admirably adapted to this purpose by the nature of its grasp; and as it brings several points into contact with what it examines, it has so many additional chances, that if one should err, the error may be corrected by the others. Monkeys, which have hands, use them as we do, and by means of this member they become a match for their adversaries, and domineer in the forest; for by this they wield a stick and beat their enemies, or, standing out of their reach, by his they pelt them with stones; so that the elephant himself is obliged to relinquish the field, to a foe that strikes, yet is too distant to be stricken. There is also a class of monkeys whose seat of feeling is in their tails; with these they will often catch animals, &c. and by twisting it round them, prevent their escape; by this too they will swing on the branch of a tree, sprawling the rest of their sweet persons in all manner of attitudes, with great activity,—secure from falling, while suspended by their tails: they will also throw themselves from the top of a high bough, and while falling, with their tails clasp a lower one, from which they dangle, grin, and chatter. The seat of feeling in the elephant is his trunk, and he possesses this sense in no trifling degree; with this he will pick up a very small object, and with this, when provoked he will inflict terrible blows. As to birds, it is somewhat difficult to assign any specific part as the seat of feeling in them, or to determine whether those which have remarkable nerves in their bills, do really select their food by the smell or by the touch.

On the whole we infer, that the nerves are the medium of feeling; that they are usually distributed throughout the body, and wherever motion is carrying on, of which they are probably the agents; that without nerves is no sensation: where the nerves are few there is little sensation; where they are numerous superficial,

superficial, or capable of intimate contact, sensation is constant, lively, and powerful. Even access of air makes considerable impression on them, and must be prevented. Nerves are capable of injury, also of restoration. They spread where arteries and veins take their courses (as in extraneous swellings), and are greatly affected by irregularities, which would be little felt in other parts of the frame.

In the last remark, I allude principally to the effect of mental passions on the nerves; which afford many curious, but inscrutable phenomena. Joy tightens and braces the nerves, renders them agile and lively; anger still more, and is even said to lighten the weight of the body by many pounds. Sudden joy has been fatal,—perhaps by detaching too much of the necessary fluid—paroxysm of rage no less. Grief debiliates the nerves; relaxes and weakens them; therefore grief is an enemy to life. Perhaps, as some passions draw away (exhales) too much of the animal spirits, others may prevent the passage of a sufficient quantity, and thereby clog and encumber these delicate parts. Extremes either way are dangerous.

Whoever would have his nerves clear, active, and in proper tone, let him command his passions, keep his mind chearful, and avoid anxiety and gloom. But, on the other hand, dissipation is prejudicial to the nerves; flights and vagaries are no less injurious than melancholy depression. Habitual peace of mind, habitual self-controul, much industry, and a little vanity (*fiat mixtur a-jecundum artem*) is an excellent prescription for prevention of nervous disorders.

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OF SEEING.

OUR last discourse related to a sense whose exercise was confined to a narrow compass, and incapable of acting at a distance; but, within its proper limits, exactness and perspicuity amply compensated for the absence of excursive powers: at present our attention regards a sense which exhibits many qualities reverse from the former. Unlimited in its excursive faculty, unconfined in its range, but subject to illusion, and easily deceived, such is the sense of SEEING! one of the most wonderful instances of divine operation; a sense not bestowed on every creature, not lavished on any, possessed in very different degrees by various tribes

tribes of animals, and among mankind alone, were we to look no further, offering great variation of powers, and capabilities.

If we ask, in what rank of creatures sight is more extensive, most determinate and accurate, most powerful, and subject to least indisposition? we must refer at once to the tribes of birds; and among these, it should seem, to birds of prey. It is true, the lynx among quadrupeds is proverbial for keenness of sight, and not without reason; yet, in extent and accuracy of vision, he must yield to many birds. We shall instance the eagle in proof of our position. The highest elevation to which an eagle soars, is I believe unknown: but when we consider that he inhabits crags of the highest rocks, and towering steeples of mountainous pinnacles, that from these he rises up to heights which fatigue the eye to trace him, if he does not totally disappear from observation; we are easily induced to admit, that a much more extensive prospect opens to his view, than any quadruped is ever in a situation to survey. What a vast sweep! what a wide extended circumference lies before his inspection! If, when we ascend to Snowden's top, we see adjacent countries lying as in a map, we trace the courses of rivers, the coast of an island, the dimensions of a sea, the rocks of a remote kingdom;—if, from the top of Etna, we behold the glorious sun rise in resplendent majesty hours before he visits parts beneath us; to how much farther may the sight of an eagle extend, and how many provinces, and kingdoms, and states, may his view include!

Birds which do not rise high, by their facility in mounting upon trees, enjoy an enlarged horizon: those of the long-necked form possess no small advantage, in having the seat of sight so high above the level of the plain: this appears in the ostrich, which, inhabiting deserts whose barrenness admits no impediment to his view, by means of the elevation of his head, enjoys a range of vision far exceeding that of any creature naturally prone.

Extent of vision, and accuracy of inspection, are confessedly distinct qualities; it is therefore natural to inquire if these birds, or birds in common, distinguish objects at heights in any degree correspondent to what we have mentioned. We can, on this subject, only reason by analogy, and conclude from circumstances. Myself a wren, not an eagle, I presume not to determine for the supreme of birds; but this is certain, that from heights when he is to us invisible, an eagle will dart down on his prey; that a hawk, a kite, and other birds of prey, when appearing as mere specks amid the clouds, will, with unerring aim, seize the warbler on a bush; that water-fowl will discover fish at considerable

able depths in water, and the gannet, or solan goose (which is ranked among the *boobies*), "will soar to a vast height, then darting headlong into the sea, make the water foam, and spring up with the violence of his descent;" and, though a booby, seldom or never miss his finny prey. But it must be owned, either that he distinguishes little or nothing beside his prey, or that his other booby qualities exceed the impulse of sight; for "one of these birds flying over Penzance, and seeing some pilchards lying on a fir plank, in a cellar used for curing fish, darted itself down with such violence, that it struck its bill quite through the board (an inch and quarter thick), and broke its neck." By such a trap they are often caught by fishermen. But this sharpness of sight is not confined to birds of prey: domestic poultry, especially when engaged in the charge of their young, are equally observant. A turkey hen, for instance, will give the alarm to her brood, and keep them in concealment for an hour together, when, with all our endeavours, we can scarce discern the bird which occasions her terror.

I think it clear, after these relations, that quadrupeds cannot vie with birds in the faculty of sight; neither indeed, have they occasion for it: for, beside being confined in the *sweep* of their vision there are numerous obstacles on a level with it, through which no sight can pierce; in a forest, the shadowing thicket, the deep glen, and embowering branches; in cultivated lands, the bank and the hedge, if no other hindrances. On extensive deserts, indeed, animals have more occasion for keenness of sight; and certainly that of the antelope is very lively.

We regard fish as having the smallest share of feeling; we are not equally certain whether they have the smallest share of sight. It seems indeed probable, that in so dense a medium as water, especially when foul, or agitated by storms, the rays of light, being greatly obstructed, should consequently be incapable of depicting images remote from the original object. If this be true, and if the impulse of light suffer considerable diminution even at moderate depths (which is likely, from circumstances noticed in a diving bell), then the bottom of the sea, where very deep, is closely allied to the shadow of darkness. It should seem to be, in reality, occupied by creatures to whom abundant light were useless; who living on prey which comes within their reach, rather than seeking after it, were obliged for their maintenance at least as much to feeling as to sight. Fish of the active kinds, though occasional visitants below, may nevertheless be attentive to what passes above; at least we are sure, that sharks will rise from great depths to seize unhappy swimmers: they

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are sometimes seen, from as deep as our eyes can discover them, making right for the object of their pursuit, as if they had long had him in view. Many kinds of fish are void of every appearance of organs for the exercise of sight: others, though not void of organs, seem to possess but feeble and indistinct preparations for the sense, and to enjoy the sensation in a very inferior and restricted manner.

We have hinted at the *telescopic* sight of birds, whereby they discern very remote objects; let us now consider the *microscopic* sight of insects, whereby their visual powers are strengthened and multiplied beyond conception. I imagine that insects in general (for there are exceptions) see but to a small distance, a few feet or inches, before them: but within the respective distances, which I may call the range of their vision, I suppose they see objects very disproportionately magnified; that a hair is to them as a tree to us; that their fellows in their estimation, equal our grenadiers, and often are perhaps gigantic; that their cells are magnificent palaces, their enjoyments on a great scale, replete with convenient elegance, in the immediate taste; and what not? Raillery apart, I incline to think, that the lower we descend in size and apparent powers, among the tribes of insects, the greater are some of their properties; and as, by actual discoveries, we know the principles of optics to be unlimited, it seems not absurd to suppose their higher degrees are bestowed where intensity seems likely to compensate for the absence of generality. If I recollect right, the famous LEUENHOECK attempted to use the eye of an insect for a microscope, and found it an amazing magnifier, — though he could not readily adjust it: but if their food bear a proportion to them, as that of larger animals, what must be the power of that insect's eye, who is himself the *thirty thousandth part of an inch* in length, that he may select and chase his prey! his anatomical maintenance!

There is a strange power attendant on sight, which, if we may rely on some averred facts, is remarkable in the rattlesnake, that charms its prey into its mouth. The inhabitants of Pennsylvania are said, to have frequent opportunities of observing this strange fascination: The snake is seen basking at the foot of a tree where birds and squirrels make their residence. There, coiled upon its tail, its jaws extended, and its eyes shining like fire, the rattlesnake levels its dreadful glare on one of the little animals above. The bird or the squirrel, too plainly perceives the mischief meant it, and hops from branch to branch, with a timorous plaintive sound, wishing to avoid, yet incapable of breaking through, the fascination: it continues for some time in feeble efforts and com-

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plaints, still approaching lower and lower toward the bottom of the tree, untill, at last, as if overcome by the potency of its fears, it jumps down directly into the throat of its frightful destroyer.

This, if true (for it is debated), is wonderful : yet perhaps not altogether incredible, when we recollect the power of the eye among mankind. Hags, and witches were formerly accused of injuring their neighbours by "evil eyes," whose nefarious spells defied the remedies of physic. In our days, much greater effects of irresistible fascination accompany the glances of eyes bright and sparkling : not the incantations of Medea or the conjurations of Circe, ever equalled in *charms* the eyes of an assembly of British Ladies.

Without appealing to unhappy, because guilty, instances of fascination by the power of the eye, I shall hint, that very forcible ideas are unquestionably received by this organ. A person standing very high (on a ladder, suppose) is safe while he looks straight forward, but is in danger of falling, if he looks down. Those unused to scaffolding, find their heads become giddy (*swim* as they express it); and their senses fail them. Very steady fixure of the eye, while a person is in progressive motion (as in a boat) confuses the mind for a time, and often occasions swooning. I recollect a melancholy instance, of a young lady on her voyage to India, who standing in the stern-gallery of the ship, and very earnestly watching a shark which was basking in the water, by some such *deliquium* actually fell from the gallery into the water, and became his prey. Astonishment usually enters at the eye, and often seizes the party so strongly, as to supersede the power of motion. In fact, if we regard a creature which alarms us, we look at his eye (and a lion is affirmed to be vanquished by the steady aspect of the human eye), or if we converse with a friend who delights us, we look at his eye, or if we wish to attract the notice of another, whether at a little distance, or not, we look at his eye. In fighting, we watch the eye of our adversary. In civility and courtesy, in affection, and esteem, the eye is the organ of our study. It seems to be a principle acting at a distance, as well attractively, as repulsively, but whether to the degree affirmed of the rattle-snake, I will not assert. In our own country, the fox is said to bring down a cock or hen from the roost, merely by the steady glare of his eyes, confusing by his stare (for so I account for it) the creature on which he fixes his sight; and this well known fact seems to support the history of the snake.

Sight is not generally distributed over the frame, as we observed of feeling, but is restricted to certain organs; yet because restricted, it is not therefore sparingly bestowed. I do not recollect

fect any animal possessing one eye only ; sight, where necessary in any degree, is more or less indispensable ; therefore, to provide against its deprivation by accident, benevolent wisdom has contrived, that it should not be totally lost at a single stroke : likewise, as demonstrating its indispensibility, it is varied in powers, according to the situations of creatures, in the constructions and numbers of the organs engaged, in their positions, in their properties. It is true that certain water insects have been named *monoculi* (one-eyed), yet on repeated examination, their apparent one eye is found to be composed of four. The seat of sight is in the head, for reasons which we formerly hinted, as being more immediately connected with the sensorium, where the united testimony of the senses contributes to mutual correction ; and, in most animals, that it might enjoy the advantages arising from the elevation of that part, and from the powers of extension belonging to the neck.

Is sight accurate, or inaccurate ? When compared with the determinate judgment of feeling, sight must be considered as liable to frequent deception ; it is reasonable to suppose, that what includes objects so numerous, so varied, so remote from each other, capable of endless combinations, and intricacies, should sometimes be mistaken. What admits all at the same time, and transmits ideas of each at the same instant, may be pardoned, if it form incorrect opinions on some. That multiplicity should include error, and prevent discriminating accuracy, is not surprising, especially when we recollect the medium through which this sense is required to act—the distances to which it extends—the similarity of some objects to others, and—the arts of ingenuity, whose studies have been uniformly directed to the delight, by deception, of this particular sense.

But there are also inherent inaccuracies belonging to this sense, and resulting from the number and nature of its organs. From the number of our eyes, we may, without hesitation, admit that we see objects double, *i. e.* that each eye transmits to the sensorium an idea of the object seen. We find also, that each eye does not see precisely the same points of view as its fellow ; for by merely taking advantage of some steady object near us, and surveying first with one eye, then with the other, what may be called its *back ground*, we perceive the apparent place of the object changes, and a considerable *parallax* ensues. In fact, by the relative situation of the eyes, we see as it were, partly *round*, what we inspect.

Beside this, there is in each eye, a spot destitute of vision : CHESELDEN relates the history of a gentleman, who having lost

one eye, in passing through a hedge received in the eye remaining a wound from a thorn, in that particular spot where it was to this single eye invisible, though it would have been visible to the other eye, had he possessed it. This circumstance proves the mutual obligations of the eyes to each other.

Another imperfection of sight is, that objects are actually *seen* inverted; rays from those above appear below, rays from those below appear above, correspondent to the effects of certain kinds of lens glasses, or to rays passing through a crevice into a dark chamber: and I think I remember a story of an idiot, who *draw* all his figures *topsy-turvy*, not having accurately corrected this sense by the usage of others.

Nor is sight capable alone, of determining distance, or judging of magnitude; all rays of light which enter the eye, have equal effects in painting there a picture, that picture therefore is deceptive, till the judgment is regulated by repeated information from other quarters. This is notorious in children, who consider all things as within their grasp: and with regard to very extensive distances, as those of the heavenly bodies, sight is always inaccurate in its estimation. The rainbow is a deception of sight, whose principles we have explained; no such coloured arch actually exists in the cloud, but is illusory, nor are less illusory the sparkling rays which in the dark surround a candle, a star, or other luminary. These irradiations are accounted for, by considering the number of rays which pass through the eye-lashes, and are by them divided into parcels, or reflected from the eye-lids, of which only some reach the seat of vision: any tube prevents them, by preventing the access of so many false rays; or they may be checked by a pin-hole in a card. In fact, they only appear at a distance; on close inspection, we are convinced of their non-existence; they are deceptions of sight.

There are other deceptions of sight, which are very rare, and highly curious; such is the fairy Morgana of Sicily, in which the sea assumes the appearance of fields, mountains, cities, and a variety of objects unlike itself: we have an account of similar visions seen in Greenland,—a climate sufficiently different from that of Sicily. These are understood to be reflections from the atmosphere (at that time unusually dense) of whatever objects are behind the spectator, even trees, animals, &c. But similar appearances sometimes arise from the peculiar state of the atmosphere *through* which they are seen, and these seem allied to mock suns, halos, and other (seemingly) celestial phenomena, which, like the former, are not realities, but visionary illusions. I have elsewhere suggested a few other particulars wherein sight is liable

ble to deception: as in the course of a ship, when objects around us furnish fallacious comparative proportions, lamps at a distance seen in obscurity, and some others. These we introduced in our second set of Lectures on the Arts of Design.

We come now to the MODE of ACTION, adopted in the sense of seeing: To understand which with more effect, we must recollect somewhat of our remarks on the nature of Light, by whose agency this sense is enabled to act.

We considered light, as an extremely subtle, elastic, attenuated, but vigorous fluid, whose impulse though insensible to us, yet produces very remarkable effects. This fluid is weakened by *divergence* of its rays (as in the instance of the moon light), but is strengthened by their *convergence*. Add to this, the self-evident power of contrast, and we have the principles on which the eye is constructed.

Contrast, you know, heightens by its opposition every effect; black upon white is blacker, white upon black is whiter, red upon blue is redder, blue upon red is bluer, than without such opposition;—this considered, we infer, that to give light its full force, it must be contrasted by darkness. The seat of sight is therefore placed *deep*, in a hollow, where darkness may naturally be expected, thereby rendering a little light more efficacious than much in open exposure.

Light, at that degree of strength which surrounds us, we have no reason to think is capable of affecting any part, even of the tenderest nerves; it must therefore be converged, or condensed, or so conducted, that more than a natural proportion of rays should unite, in forming the requisite impression; and this is the mode adopted by Infinite Wisdom. A certain number of rays (say twenty) would naturally strike against the eye, and enter it; but, if these when within the eye are, by any means, directed to fall on a surface equal to only one twentieth part the space through which they entered, it is evident their strength is twenty times what it would have been, had they continued as they originally were: I say, they affect the part they strike, twenty times more strongly than common light. This is so notorious in the case of telescopes (and the eye is a natural telescope), that it needs no enforcing.

Let us now examine a little the mechanism of the parts which produce this effect. We have said the seat of sight is *deep*; in fact, the eye is placed in a bony orbit, which affords at once security and convenience. This orbit is filled with a loose fat, as a soft medium for the eye to rest on, forming also a properly-shaped, but not inflexible, socket for its motions. In the upper
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and outer part of the orbit is seated the lachrymal gland, which furnishes a water to cleanse and moisten the surface of the eye, which we often *spread*, by closing the eye-lids: though without that design. The eye is orbicular, for readier motion every way. The first membrane of this orb *covers* the white of the eye, and also *lines* the two eye-lids: by thus *returning*, it closes up all passage to the back of the eye. As part of the internal contents of the eye is liquid, it is surrounded by a strong case to enclose them safely; this is in one part transparent, and is there called the *cornea*, but elsewhere the *sclerotica*. Under the cornea (or horny transparency) lies the *iris*, which is an opaque membrane, differing in colour in different persons: the middle of the iris is perforated, and this perforation is called the *pupil*; immediately under which lie the *ciliary* processes, in radii, whose contraction dilates the pupil, whereby it transmits more light. The pupil closes (to exclude light) by the circular fibres of the iris, its proper membrane. Under the sclerotica is a membrane called *choroides*; and under the choroides lies the *retina*, which is an expansion of the optic nerve, like net-work in appearance, upon which the rays of light striking, produce the sensation of sight.

In the membranes mentioned, we find no preparation for converging the rays of light, without which we have asserted its insufficiency; these we discover in their contents, which are, three humors; the *aqueous*, the *crystalline*, the *vitreous*. The first not only defends the second, but serves as an assistant to its motion. The crystalline (rather solid than liquid) is in shape a depressed spheriod. The vitreous humor lies behind the crystalline, and fills the greater part of the eye, *i. e.* from the interior surface of the crystalline, to the retina. Let us now examine the use and properties of these humors.

Light, we observed, when entering a denser medium from that in which it was moving, was attracted, and drawn out of its course (as out of air into water or glass); this effect it experiences, when striking on the cornea, whose refraction equals that of water (four to three): here is a first advance toward convergence of the rays of light; but this ratio carries its focus *beyond* the retina, where only it can be efficacious: therefore, the crystalline converges them closer, and they are yet more precisely directed by the vitreous humor, till they fall exactly on the retina in their full force, and produce a perfect sight. There are persons whose sight is imperfect, by reason of the rays of light forming a focus *before* the retina, as in other persons their focus is *behind* the retina. The retina being, as we said, an expansion of the optic nerve, transmits its impressions

impressions to that nerve, and thereby to the sensorium. If, as we hinted in our last Discourse, every part has its nerve, should we not rather say the retina is composed of those smaller nerves, which in the optic nerve appear as one bundle, and these smaller nerves transmit each of them its intelligence to the sensorium, where their effect is united? May we hereby account for the existence of those *spectra*, or images of objects seen *after* we have excluded the objects themselves, by shutting our eyes? an effect remarkably attendant on luminous objects.

This accurate and curious contrivance has ever excited wonder and admiration: I have no need to expatiate on such becoming sentiments; to genuine good sense and reflection, such sentiments arise naturally, and with greater effect than those suggested by art or declamation. Yet give me leave to remark some of the most striking peculiarities attendant on the eye.

1. Sight does not depend on our wills; while our eyes are open, we must see: but, if inclined to forego this sense, we have the power, by closing our eye-lids. It should seem by this provision, which, when about to sleep, we always employ, that sight is the most active of the senses; for the ear remains open, yet we sleep, and sometimes, feeling not carried to pain, scarce awakes us: but the eye seldom opens without rousing the whole person.
2. The instinctive attention of the eye-lid, to close and defend the important organs of this sense; this instantaneous motion, is performed before any commands to that purpose arrive from the sensorium. Happy for us, that hereby those lesser and scarce visible motes, which almost elude our sight, are prevented from doing that mischief which otherwise they might.
3. The regular and ready adjustment of the pupil to that degree of light which surrounds it; this also is involuntary, and proceeds without our determination; but not so rapidly as the former principle; for out of darkness entering sudden light, or out of light entering sudden darkness, we find ourselves for a little time unfit for sight in either.
4. The happy adjustment of the interior humors of the eye to the distances of objects, or to that intensity which inspection of them requires.
5. The projection of the cornea *before* the true *sweep* of the eye-ball, whereby an enlarged extent of vision is gained *laterally*, without injuring the accuracy of that which is direct; also, its hard, though transparent substance, whereby it is less sensible of injuries, and more capable of defending the aqueous humor behind it. It is obvious also, to remark the well fortified situations of the organs of sight; their almost surrounding bony defences; nor are less remarkable the number of muscles employed in the motions of the eye,

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above, below, around ; those to the eye-lids ; the construction, situation, and uses, of the eye-lashes also demand acknowledgment : in short, whatever contributes to the action or to the perfection of this sense, is extremely sagacious in contrivance, accurate in effect, and happy in application.

Such are the general principles of sight : that they should be adapted to various services, might be expected, from the wisdom apparent in their very existence. For instance, the pupil is round in men, and in animals which are the prey of both birds and beasts, this form permitting vision every way alike ; but, in graminivorous beasts, that are too large to be the prey of birds, it is *oblong horizontally*, which enables them to view a large space on the earth ; while cats, &c. which climb trees, and prey as well on birds as on animals that hide in the earth, have their pupils *oblong perpendicularly*, as fittest to look upward and downward at once.

In men, the *choroides* is of a rusty dark colour, absorbing the rays of light, and preventing reflections from it, which might confuse regular vision ; but beasts of prey have this membrane white, and by its reflections are enabled to see with little light. Brutes, which feed on grass, have this membrane of a bright green ; and this makes grass more strongly visible to them. Their sight is diminished in general accuracy and truth, but is augmented in strength toward certain objects of prime necessity.

Birds have, no doubt, similar variations : some are provided with an external membrane, called *membrane nictitans*, which covers the whole eye : this not only defends the parts, but prevents the ill effects of that glare of light to which they are often exposed ; and this varies, somewhat like the form of the pupil, as just hinted. Some creatures have a membrane above, and another below, which, meeting in the middle of the eye, may either quite close it, or leave a crevice for the passage of light ; others have only one membrane at top, or at bottom ; and in some it is placed on one side. The class of birds, which furnishes instances of sight wonderfully accurate, furnishes others, which are so tender-eyed, that open day confuses them. I suppose that owls, and other nocturnal birds of prey, are in much the same circumstances (in greater degrees) as beasts of prey : the same reflections of rays, the same colours of parts, the same repetitions, which enable a little light to be sufficient by night, are distressing by day, and transmit a huddled variety of images, all indistinct and perplexing. No wonder then that an owl by day-light will sit on a tree, surrounded by small birds, and suffer all manner of indignity, without attempting to defend himself

himself, unless winking, blinking, and gaping, may be termed defence : but, once come twilight, the case is altered, and woe to the negligent bird that remains within reach. Are not owls, &c. forced, by this circumstance of visual disability, to seek refuge in sequestered darkness during day-light ? May somewhat like this, account for those persons who can see well only by moon-light ?

To proceed :—the chrySTALLINE humor is capable of a little variation in form, and actually is varied, when we look at objects very remote, or at others near. It is said also, that fish lower this humor when out of water, and elevate it when in water. May not high-soaring birds do somewhat of the same ? This humor in fishes seems to be a perfect sphere ; by this form compensating for the nearness of its refracting power to that of water. Fish have their pupils larger than land animals, in order to admit all the light possible.

We should remark of the optic nerve, that it does not enter the eye exactly *centrally*, but nearer to the nose ; which is of manifest advantage, for had it pierced the eye in the axis, the middle point of every object had been invisible, and where all things conduce to render vision perfect, there we had not enjoyed vision at all. The nerve to each eye is supposed to transmit the images of objects seen ; it is no singular case for disease to produce *double* sight, which is long in cure. The optic nerves of fish arise from opposite sides of the brain, and cross each other without uniting : these creatures being incapable of seeing the same object with both eyes. Probably the eyes are entirely independent of each other ; the reason for the nerves crossing is not known.

We have heretofore hinted at the variation, in number, of the organs of sight among creatures ; from ourselves, which have but two, to insects which have thousands. We know little of insect vision, beside what I have offered, or of what ideas they have of objects who see so many at once, or whether they know it to be but one seen repeatedly : we are ignorant what effect the sight of objects, by the different aspects of his two rolling eyes, has on the *cameleon*, who looks at once forward and backward, upward and downward, directing one eye this way, the other that way. We are ignorant of much that relates to this sense ; but we observe, that the eye is constantly so placed as to observe food, and to warn of danger. Flat fish expect enemies from above ; on their upper side then stands their eye : insects are exposed all round ; their eyes, therefore, project greatly before their head every way. In fact, their heads of some seem to be

almost all eyes, that some or other of their *sights* may do its duty, and transmit the image of every object.

There is little need of an eulogium on the sense of sight; our perpetual use of it is its highest eulogium: without it, what were the celestial tinted atmosphere around us, what the verdant carpet our natural residence, what the bright beams of morning, or the glowing tints of evening; what the yet brighter beams, and more glowing tints, where Nature's utmost art perfects the principles of colours; by contrast, yet union,—of delicacy with depth, of indetermination, with precision; by choice—of pleasing tints, heightened by variety, and by purity;—in vain, without sight, were BEAUTY of form or colour; vain were the charms we most admire; and were these vain, what were grateful? or what could compensate for enjoyments lost, in losing the sense of sight.

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OF HEARING.

THE advantages of VOICE are highly important and beneficial: by this faculty we express the sentiments of our minds, the sensations of our persons, joy or sorrow, exultation or grief. The tender accents of love and friendship, of sympathy and compassion:—the fierce howls of rage, of disappointment, of despair, are distinguished by their influence on the voice; but of what use were voice without an auditor?

HEARING is justly reckoned among our most valuable possessions, it is indeed less extensive in its range than sight, yet frequently it surmounts obstacles which hinder the exercise of that sense; and well for us it possesses this power! as thereby we receive important informations, which otherwise must escape us.

Sound is the immediate object of hearing, and by its divergence extends in every direction, visiting a thousand auditors with the same ease as one, and freely communicating tidings, wherever attention excites the hearing ear. Sound travels rapidly, and in a few seconds of time relates occurrences at a considerable distance; hence a single bell alarms a multitude; and hence the report of a cannon is fraught with general information.

Sight is the most extensive of our senses; hearing is the next: we see even to distant worlds, but we hear nothing of what passes there; for we can direct sight otherways, we can avoid regarding those or other objects; nay, we can totally preclude

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all objects, and forbid their making the least impression on us ; but we cannot forbid hearing ; had we then been forced to hear what is totally alien from us, it would have been perplexity to no purpose. On the same principle, extension of this sense beyond the limits we find assigned it, would produce incessant confusion. What a strange medley of heterogeneous principles would fatigue us, what impertinent intrusions would distract us from our immediate concerns, were our hearing too sharp, too extensive, or too powerful ! The communicative whisper would then be impracticable, and the very relation of a secret would destroy its secrecy. It might resemble Sir JOHN MANDEVILLE's account of *frozen words*, in his voyage to the North Pole ; these, when *thawed* by a change of weather, discovered all the sentiments uttered in the vessel during the frost, truly a *sweet* composition of vows, oaths, and execrations, repinings, wishes, and discontents—little *debased* by expressions of kindness, respect, or devotion.

Sounds are more or less *intense* ; in proportion to their intensity they more forcibly agitate the surrounding atmosphere ; a forcible agitation of the atmosphere extends its effects further than a bare feeble motion of that fluid ; and thus we account for the distance to which sounds travel. That when this ærial impulse is nearly spent, it should furnish a very weak sound, is natural ; that when we are nearer to the origin of the sound, where it has travelled little, and its impulse is vigorous, it should be stronger, is also natural : thus we account for the *strength* of sound. There is also a *heightening* and *deepening* of sound, as in the scale of music, where *Gamut* is the standard Note : this is explained, by considering the relative vibrations of the higher and lower sounds. The quickest vibrations (of a string for instance) are the *highest* and *shrillest* tones ; the slowest vibrations are *deepest* or *gravest*. In stringed instruments, the lengths, magnitudes, and tension of the strings, influence their sounds.

To produce distinct sound, requires thirty vibrations in a second of time ; less will not become audible, more becomes confused ; extreme rapidity (as a thousand vibrations in a second) forms a mere whiz, or confusion. All sound should seem to originate from vibration. If a person pass briskly his wetted finger round the brim of a drinking glass, by its pressure he will cause tremors or vibrations in the glass, which, in consequence, will sound, and continue sounding, while the motion of his finger continues, and this may be carried to such rapidity as to break the glass. The same principles account for the tones of wind instruments, which sound by the vibrations of a column of air,

contained within them, and actuated by the voice or the breath. As in strings, the shortest are the high notes, so in a flute, the shortest holes emit the highest sounds. Whether sound really originates from the string, or from the *re-action* of the air displaced by the vibration of the string, has been doubted: probably from the latter; hence the sound of a cannon is so vehement, because, the vacuum occasioned by its firing, being nearly perfect, the surrounding air rushing with great violence to supply this vacuum, is proportionately agitated. Somewhat like this, in miniature, occurs on re-admission of air to the exhausted receiver of an air-pump.

Do all creatures possess the sense of hearing? Certainly not: yet in proportion to their numerous varieties, we consider this sense as a blessing rarely withheld. Creatures void of sight, are often void of hearing also, which seems to be of little value, where the most extensive sense would be either useless or injurious.

It has been debated whether fish hear: but with regard to the major part of the active kinds, at least, it is consonant to reason to suppose they do, as well because we find organs seemingly adapted to the sense, as because violent sounds affright, and perhaps *shock* them. If I mistake not, lobsters are said to cast their claws at the noise of thunder, as also at the report of a great gun, which resembles thunder; and a salute is said to be a frequent threat by men of war to lobster boats, when purchasing those fish, to insure good ones. I think also, that few fish, if any, appear on the surface of the waves during a thunder-storm; and beside what has been said of frightening a shoal of herrings, by firing a musquet, it is certain that a stone, &c. thrown into a rivulet, out of sight of fish, will yet disturb and disperse them. But we must remember in what sound consists; that it is a pulsation of the surrounding medium, affecting our nerves with sensations which, transmitted to the sensorium, we call sound; such pulsations in water, proportionate to the density of that medium, and to other circumstances, probably affect fish, as aerial pulsations do ourselves. Water is known to transmit sound, since noise made at a considerable depth, has been heard, in air, by those who attended to it; as has been experimented by divers striking stones together under water.

As to beasts, we consider them as possessing this sense in different degrees; in some it is extremely acute, and impressible, and in fact is a substitute for those exquisite powers of other senses, by which other creatures trace their prey. This we have hinted at in the lion; we conclude, in general, that wherever is voice, there is also hearing; birds of song, therefore, are considered

dered as possessing this sense in perfection, I mean great accuracy of judgment in determining upon tone. There is another kind of perfection, *that* relating to distance, which, probably, appertains to birds of prey; and in this, I think it likely, they are unrivalled. It seems scarce probable, that the lion himself can hear so far as these kinds of birds.

But, though we said song birds are extremely accurate in determining between tones very little higher, or lower, than each other (as we gather from their modulation of tones with great nicety), yet, probably, the human ear is the most exact of judges in this matter. Musicians will distinguish between tones, which to unpractised ears are alike, and blind persons (especially) often ascertain by their precise judgment of sounds, many things, persons, or places, which to those less attentive require inspection. As instances of fallacious judgment in birds, Parrots, which are notorious for loquacity, will often talk to themselves, and mistaking their own voices for those of persons to whom they have been accustomed, will hold down the head, hold out a claw, dance, and do many other things, as directed by *their own bidding*.

This reminds us of the utility arising from the providential differences of voice, not only among mankind, but among animals also, whereby parents distinguish their own young, from among many of the same race, and the young distinguish their parents. What slight, yet determinate, variations among ourselves contribute to this, are probably at least as effectual among animals. No two sheep *baa*, nor two cows *low*, exactly alike; nor do hens *cackle*, or ducks *quaack*, so precisely similar that *we* cannot distinguish them, a faculty which no doubt their own young possess in much greater degrees.

The seat of hearing is fixed near the sensorium, for the same reasons as sight is; and, like sight, it has more than one organ, as well for precision, and accuracy of information, as for security against its deprivation at a single stroke. Many persons are deaf with one ear, yet hear sufficiently well with the other.

The principles adopted in constructing the ear, are not totally different from those adopted in the eye; in both, the seat of the sense is *deep*, and in both the active principle is *converged* to a focus; but they differ, in that the rays of light are converged *directly* (because light passes in straight lines); whereas the rays of sound are conveyed by (and after) repeated reverberations, because ærial undulations extend all around, and act in every direction. The general construction of the ear, therefore, is externally broad, extensive and capacious, that it may collect
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as much sound as possible ; but it narrows by degrees, that it may condense the sound it has collected ; not too suddenly, that would shock us, nor too slowly, that were to admit the possibility of its being too late to excite the mind toward subjects requesting assistance.

Following the progress of sounds from the external parts of the ear, to where they principally raise sensations, we find a passage of unequal dimensions, leading internally toward the brain ; this passage is lined by a glandular membrane, which furnishes what is called the *cerumen* or ear-wax, whose use is to prevent the passage of insects, &c. into the ear, and to keep the external air from injuring the parts of it ; for as we cannot close our ears, and have no means of excluding offensive animacula (as the eye-lids do from the eye), this bitter substance answers the purpose, and that at all times.

Proceeding in the auditory passage, we find the *membrana tympani*, or drum of the ear, which is a fine membranous expansion, extended on a bony ridge, almost circular ; this membrane does not entirely close the passage, but has on one side a small aperture covered with a valve. Though highly beneficial, to the sense, this membrane is not the seat of hearing. Behind it is a cavity, containing three very small bones, denominated from their resemblances, as the hammer (*malleus*), which is extended into the middle of the tympanum, and is at its other end articulated to a bone called the anvil (*incus*), which is also articulated by the intervention of an exceeding small bone called *orbicularis* to a fourth bone, called the stirrup (*stapes*) ; these are usually regarded as the *fine quâ non* of hearing. They tighten, or relax, the *membrana tympani* without our knowledge, much on the same principle as the pupil of the eye is enlarged, or narrowed, and much to the same purpose. By extending the tympanum, the effect of a little sound is increased ; by relaxing the tympanum, the force of sound when too powerful is diminished. From the cavity behind the tympanum, is a passage to the mouth, through which sounds are, under certain circumstances, transmitted to the auditory passage, without the interposition of the tympanum. This cavity also contains a portion of air. To the stapes or stirrup, belongs a muscle, whose duty is to withdraw the stapes when directed, from a small hole, which it otherwise covers ; this hole, and another near it, leads into a cavity called the *vestibule*, connected with other cavities called the *labyrinth* ; comprising the *cochlea*, and the *labyrinthine* canals, which (like a snail's shell) forms two turns and a half spirally, and is divided into two parts by a spiral *lamina*, or thin division. A very delicate

ate membrane lines the cavity of the labyrinth, and is an expansion of the auditory nerve (as the retina is of the optic nerve), and the prime seat of the sense of hearing. There are other openings, and other cavities visited by nerves, which transmit to the brain the sensations they receive from sounds.

To what a surprising structure have we been attending? What provision, not only that weak sounds should have their effects, but (especially) that strong sounds should not be injurious! and this is more to be apprehended than the former, as, by their violence, they might burst the tympanum. To guard against this, bombardiers or others, when firing very large cannon, fill the external ear with somewhat soft to close it; but if this substance should by any means enter the passage, it is very dangerous, and not to be extracted without difficulty. Observe the skill manifested in the inclosing a small quantity of air, free from access of external air, and consequently unaffected by atmospheric variations; for air being the medium of sound, its services could not be dispensed with even here. Observe, that one hole is closed by the stapes, another is open, which is a contrivance happily adapted to the transmission of more or less sound, according as excited by attention.

The position of the membrana tympani, is in men and brutes, almost *horizontal*, but inclined toward the external passage; this being the best situation to receive sounds, great part of which often is reverberated from the earth. In men and brutes, it is *concave* outward, but in birds, *convex* outward, so as to make its upper side nearly perpendicular to the horizon: which seems adapted to the reception of sound when high in the air, where little, if any, is reverberated.

Hearing, like sight, gives us notice of remote objects, and is subject to similar errors. We receive from it no distinct intelligence of the distance from whence a sound proceeds; a great noise a-far off, and a small one near, produce the same sensation; and, unless informed by some other sense, we cannot distinctly tell whether the sound heard be great or small, nor till we have learned by experience the peculiarities of the sound we hear, can we judge of its distance.

It often happens, that persons hear differently in point of accuracy with one ear from what they do with the other; these have, what is called by musicians, a bad ear. Mr. Buffon, after many trials, always found that their defect in judging of sounds, proceeded from the inequality of the two ears; receiving by both at the same time, unequal sensations, they form an unjust idea; as they hear false, they also, without knowing it, sing false. These
persons

persons also frequently deceive themselves with regard to the side from whence a sound comes, generally supposing it to come from the side of the best ear.

Hearing is a much more necessary sense to man than to animals: With those it is only a warning against danger, or an encouragement to mutual assistance: In man, it is the source of most of his pleasures; without which, the rest of his senses would be of little advantage. A man born deaf, must necessarily be dumb; and his whole sphere of knowledge, be bounded by sensual objects.

As it would be unpardonable, in a discourse on hearing, to omit the pleasure this sense receives from music, I shall introduce a few hints relative to that captivating science.

Sounds become pleasing, not by one continued tone, how loud or swelling soever, but by their successions in agreeable proportion.

Musicians have contented themselves with seven different notes of sound, which sufficiently answer all the purposes of pleasure. The differences of smaller proportions are so imperceptible, that the ear is rather fatigued than pleased in marking the distinction. However, they have admitted half tones; but where music is in its infancy, these are rejected. The Chinese have neither flats nor sharps in their music; but the intervals between their notes are in the same proportion with ours, as are those of most, if not of all barbarous nations.

The ancients relate a thousand strange instances of the effects of music. The story of Arion's harp, that gathered dolphins to the ship's side, is well known; and what is remarkable, Schottæus assures us, that he saw a similar instance of fishes being allured by music.

However, this be, we have many striking accounts of the influence of music; and it must be admitted that, on particular occasions, musical sounds may have very powerful effects. Horses and cows in a field will listen to music. Dogs are well known to be very sensible of different tones in music; and sometimes sustain very ridiculous parts in a concert, where their assistance is neither expected nor desired.

If, as we related, the impressions received by sight are extremely powerful, and sometimes even fatal, I see no reason to reject accounts which assert an equal power in the sense of hearing; that by this, the spirits may be raised or depressed, may be hurried or soothed, and correspondent ideas not merely transmitted, but *impressed* on the mind, seems very supposable, and indeed is a well-known fact; that where its powers are augmented by other

circumstances

circumstances, it may rise even to rage and phrensy, may also be granted; nevertheless, we must stop short of granting all that has been said in its favour by musical enthusiasts; since no modern musician armed only with his fiddle, would venture to encounter a wolf, nor will harmonious sounds soothe the anguish of a broken limb, or contribute to set the bone which accident has dislocated.

To know the value of hearing, we should consider its services in the dark, wherein we are naturally most attentive; thus circumstanced, hearing seems to be a warning sense, which, by giving notice of danger, permits preparation for avoiding it; and perhaps partly on this account, sounds heard at night, are more strongly impressive, than when day-light admits completer knowledge of our situation, and that of things around us.

But, more especially, to know the value of hearing, we should reflect on its deprivation: without it, how useless were every endeavour to communicate sentiments and ideas by discourse! how utterly illusive the pleasures of society!

“The feast of reason, and the flow of soul,”
the very tenderesses of our nature, if consigned to silence: without hearing, vain were every attempt to improve the mind (should we desire improvement) by science or learning; and vain the attention of the most respectable assembly which the most competent instructor could have the honour to address.

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OF SMELLING.

NATURE is replete with evidences of its great Author's beneficence; some of them we enjoy, if not completely, yet in considerable and advantageous degrees; others are either weakened in their properties and effects, or our powers of perception are vitiated, so that they little affect us. Man was originally destined to inhabit a garden, fragrant as well as verdant, and highly delightful to that sense whose office was to judge of odours. But in the present state of things, delight is not a constant attendant on odours, for some are extremely offensive; nor only have they lost their property of giving pleasure, but with their fragrance they have lost their innocence; and now, not a few are deleterious and fatal.

I am unwilling to allow that, even in those faculties which belong to the animal part of our composition, man is naturally inferior

inferior to his fellow creatures : I rather imagine that even in these, he was once their superior : and as we have found reason to conclude that he still is, in the exercise of his touch and his hearing, so perhaps he was in that sense wherein he now seems most remarkably below them.

Smelling seems to have at least as many degrees as those of the other senses ; and, like them, it requires repeated exercise and constant application to perfect it. This may account for its weakness in the generality of persons in civilized society ; its primary appointment seems to have been that of a kind of *purveyor* to tasting ; to judge of what was proper for food, and to determine on the qualities of whatever might offer appearances of edibility ; in civilized society therefore, where the necessity of such determination, is superseded, because food is ready selected, and only what is nutritive and wholesome is presented, the sense of smelling has no occasion to discriminate, and its judgment being dormant and unemployed, becomes gradually weakened, and at length nugatory.

Tasting, in simplicity, seems to have been attended by smelling in perfection ; whereas tasting in variety, seems to have injured smelling by depraving its accuracy. The high smells of spices, and of animal food, have by their *piquancy* destroyed the sensations arising from simple nutriment ; and in fact, among nations who decline the use of animal food, this sense, it is asserted possesses powers unknown to us. — As instances,

The Bramins of India possess the sense of smelling equal to most animals ; and can smell water, which seems to us quite inodorous. We are told also, that the negroes of the windward islands in the West-Indies, can distinguish between the footsteps of an European and a negro ; and the North-American Indians will (like blood-hounds) trace their enemies, by their footsteps. This, if true, seems surprising, since the scent of a particular tribe among them can hardly be supposed extremely different from that of any other, in the same climate, and of nearly the same manners, and modes of living. Among the Arabs have been persons of so acute a smell, that when bewildered on the immeasurable sandy deserts of their country, they have been directed in their journey, by taking up a quantity of sand and smelling to it, thereby discovering whether camels had passed that way ; and though the same sand to other persons might be perfectly scentless, yet hereby, they have ascertained the customary path.

Here, if we enquire, whether these persons equally abstain from animal food ? it is answered, Not altogether ; but, beside that their fare is simpler than ours, it is also less various, and less disguised

disguised by accompaniments. To me there seems another circumstance, not to be forgotten, in this enquiry. It is natural to suppose that persons who are much in the air, where smells abound, and which is their medium, should determine more nicely of its state, and, as it were, its *ingredients*, than those who are constantly in their apartments, or at least in their towns (which is the case of multitudes in civil society); for in a dwelling, or in a town, whatever care can possibly be taken, in respect of cleanliness, or of salubrity, many smells of a powerful nature will exist; those removed will be progressively replaced by others arising, and a familiarity, injurious to this sense, will result. This may escape the observation of townsmen, as Londoners do not perceive the sulphureous smell of their clothes, &c. which on opening a town box, in the country, is instantly noticed by the country people. The Bramins, the Negroes, the Indians, the Arabs, have no manufactories, nor great towns, nor *assemblage* of smells, but being constantly in the air they receive its influence without restraint.

It appears from what I have said, that this sense is not so important to life as that its absence should be felt with extraordinary severity, or that vitality should be impeded in its indispensable functions, by the debility of our smell. Many persons are partially, and some wholly, destitute of it, without material inconvenience; but this could only be in a state of mutual assistance arising from society. Civilization, while it improves some debases others of our faculties, by substituting other pleasures, other enjoyments, other ideas, than those of savage life; by becoming more refined, and more mental, we relinquish sensual pleasures (whose activity, however extensive, is limited), for those arising from cultivation of our intellectual faculties, whose ranges and whose acquisitions, extend beyond the narrow bounds of time and space.

It must be owned, that, did we now trust to the sense of smelling as our caterer, we should often be incommoded by false intelligence: many articles whose odour is far from inviting, especially on first acquaintance, nevertheless are both pleasant to the palate, and wholesome as nutriment. On the other hand, many smells extremely agreeable are highly noxious: we have formerly hinted at some of these; and more might easily be added. The manchineel apple is not only inviting by its beauty, but by its grateful scent; yet this is a poison of poisons! And, if I am not mistaken, many of those poisonous preparations in vogue on the Continent a century or two back (and occasionally used in later days), were fragrant,

though deadly. The Queen of Navarre was poisoned by a scented powder for her hair; and a duchess of Condé, by a plate of perfumed sweetmeats, presented to her while viewing a magnificent firework.

Smelling differs in its pleasures, together with its powers, among different nations, and in different persons: some are enraptured with a rose, others dislike it; few I believe enjoy the fragrance of a half-extinguished candle snuff, yet a person I heard of was delighted with it. The very mention of *assafœtida* is to us disgusting, but savage nations admire it. Certainly habit has great influence on this sense. Many persons at first overcome by the smell of musk, have afterwards carried it constantly about them. Most perfumes which owe their prevalence to fashion, are instances of this; and it often happens, after their fashionable days are over, that much wonder is excited how they should ever have been thought elegant. This is decidedly the case with animal perfumes (such as musk and some others); but vegetable fragrance being according to the order of nature, is liable to much less variation; that has an invariable relation to us, it is a pleasure constant, and often exquisite.

Small quantities of perfumes are agreeable, when great quantities of the same kinds are offensive. The scent is insufferable of a large store of ambergris; and though a whiff or two of smoked tobacco may be pleasant, a room full, and long continued, is very sickening to those who are not hardened smokers. When sitting down to table, the smell of food is, generally, agreeable; but after having dined, what is less tolerable than that of a tavern? This reminds us, that smelling quickens the action of the stomach, as well as influences the desire of tasting; and seems a decisive proof, that this sense has a determinate and real relation to the means of supporting life.

Smelling has also powerful influence on health: I remember reading of a physician, who, by way of medicine, daily walked a time in the warehouses of the India Company at Amsterdam, that he might inhale the fragrance of the spices, &c. there deposited, unpacked, sorted, &c.; and many disorders of the head, it is well known, are relieved by the smelling bottle. But a yet more powerful medicine is said to be, the smell of the earth itself: I have heard it considered as sovereign for consumptions; and to this opinion agrees the practice of many a good mother in the country, who makes her child walk in newly turned-up furrows. This contributes to the health of those who drive the plough; as, on the contrary, I have no doubt in affirming, that many of our manufacturers are poisoned by
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the smells of the employments they follow; as where acids are used (as in dying and painting linens, &c.), or metals of various kinds, as house-painter's colours; not to mention chymical preparations, mixtures, and fermentations.

It is difficult to say, how far persons are influenced by their smell in what are termed natural antipathies; whether the strange alarms occasioned by a cat, or other animal (though concealed), may originate from this sense; or whether those who dislike cheese are offended by its scent. Of this last article, we have a remarkable instance in the celebrated Baron HALLER, who, though devoted to knowledge, yet suffered several chests of books to stand unvisited, in a distant part of his house, because they *had* contained German cheeses. A person free from this dislike, would suppose the subjects of the books were little incitive to curiosity, or, that this disaffection acted with a power utterly inconceivable to those who are free from it.

A slight indisposition (as a cold) suspends the exercise of smelling, and sometimes changes the effects of odours; so that what was before pleasing is now displeasing, and *vice versa*.

But if we would wish to see smelling in its highest exercise, we must advert to animals whom it directs in pursuit of their prey. As most familiar to us, we may instance the cat, who discovers the haunts of mice by their scent; and indeed the scent left by these little animals, where they frequent, is very discernible to ourselves. We cannot say the same of the track a fox or a hare has taken in the open fields; we cannot perceive any scent, if we examine it directly as they have passed; no wonder then if it escape us after an interval of time. But we know there are dogs which will trace the scent when it is not fresh, will wind, and double, in every track taken by the animal chased, and when these tracks cross each other, and are extremely involved, will unravel the whole, and pursue the precise path their chace has taken: nor will they be diverted by the track of another animal of the same kind, but follow that very individual on which they opened; only their scent is embarrassed if their chace has crossed a running stream. I should suppose also, a brisk current of air must greatly enfeeble their perception; and of this, if I recollect right, beasts of chace are well aware. The dog in his wild state is very sagacious of scent, and will discern carrion (on which he often feeds) at a great distance; but, for this, commend me to the vultures, birds appointed purposely by Nature, as it were, with this design; the tainted breeze reaches them from far, and distant troops assemble to participate the regale it promises.

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Yet further, may not smelling inform certain kinds of birds of passage, that at a great distance is plenty of the food they love? When the wind has long blown in the same direction, may it not impart some of the fragrance it derives from passing over aromatics of various kinds? That it must have lost much is granted, but that it retains some, seems more than probable, if we recollect, that it occasionally brings with it the temperature of distant climates. At London we have had in February the very air, and its mildness, from Lisbon, as at other times the severity of cold from Iceland; also, it is common for ships to perceive the fragrance of the spice islands long before they are visible, and often, if the wind contribute its assistance, when they are not within two or three days sail. If then a ship's company, surrounded by smells of their own, and heedless of those from other quarters, can discern these just mentioned, what should hinder the same fragrance from affecting more *strongly* at this distance (consequently in a less degree at a remoter distance,) those creatures whose organs are especially adapted to the perfumes of the food they prefer? I do not say this will account for the particularities attending the passage of birds, but it seems the most likely manner I can imagine, of accounting for the presence of certain birds in countries where they were unknown till those countries were cultivated: and not *impossibly* it may have a general influence on migratory birds.

I should remark, that heat in general enfeebles scents; and few flowers, such as with us are agreeable, beneath the line are odorous. It seems likely also, that severe cold, by purifying the air, should banish scent: yet the rein-deer of Lapland, dig through the snow, precisely on the spot where the *lichen* (their favorite if not their only food) grows, directed most probably by the acuteness of their smelling; for no other sense seems in any degree competent to the business.

Some kinds of scents extend further than others: some are extremely pungent while near, but soon dissipated; others communicate their *haut gout* in every direction, with little loss. Particular states of the atmosphere contribute to this; but it arises also from the nature, of the odoriferous particles themselves. We smell an odorous body, because it exhales numerous portions, or particles, of its substance, which, impregnating the circumambient air are thereby diffused all around. If we take certain fragrant vegetables, we discern by a microscope little bags of (usually) whitish matter; this is termed their essential oil, deprived of which they are scentless; but this collected separately from the plant, retains its fragrance; and this separation is the endea-

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your of chemists, when they wish to procure the scented oils, &c. of various flowers. This then is a highly exalted aromatic juice, furnished by the plant, of very fine and delicate particles, which, emitted from these bags, affect us with the idea of fragrance. But this matter is fragrant not only while in the form of juice, but also when dry, yet, as in drying it has given off its most volatile particles, those remaining are diminished in number, and also in piquancy; hence dried herbs, &c. are inferior to fresh. Spices retain much fragrance, compared to productions of colder climates, because they were more highly aromatic originally, but compared to themselves in verdure, their scent when dry is feeble. May we not hence see why different scents travel different distances? The particles of some may be finer than others, and more of them may be diffused, they may float better in the air, as being lighter, or being more compact in their natures, they be less injured (*melted* shall I call it?) by its humidity, or other qualities; not to say, that some being less powerful, may require a greater number of particles to effect what others may produce by a few.

This leads us to reflect, that the odoriferous particles of bodies, though so extremely fine as to escape our sight, are yet much grosser than the elementary particles of light, or of air; they have undergone changes whereby they became parts of vegetables, or of animals, therefore are certainly not pure and primitive, but in various degrees compounded and mingled. Shall we suggest this among the reasons which contribute to the limitation of our sense of smelling? Light, which is ethereal, affects us from afar; air in pulsation, if not from so far as light, yet from a considerable distance; whereas odours being but floating particles wafted in the air, are speedily dissipated, and rendered inert. Observe also, that the finer fluids, light and air, need many advantages, and much contrivance, to enable them to produce their effects upon us: they must be strengthened by convergence, and heightened by contrast; whereas the subject of smelling affects us, if not solely by simple contact with the seat of the sense, yet by what is but little removed from it.

It is true, the nostrils are wider at their opening than higher up, yet they have neither the powerful convergence attendant on the eye, nor the curious circumvolutions belonging to the ear; but the upper internal parts of the nose being lined with a nervous expansion, become thereby the seat of smelling. We must, however, remark, that we have the power of strongly inhaling scents, thereby of assembling a greater number of particles, and causing them to act in combination, at one time, if not at one place.

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The seat of smelling varies in animals ; it is prolonged in those of long noses, and the nerves are more convoluted, so that some part or other of them may be affected by scented atoms, which have passed by the forwarder parts. In birds, the orifices which lead to the seat of this sense are very obvious, and usually on the upper part of the bill. In fish, no doubt, this sense exists, and may contribute many services to those which grope for their food : though perhaps somewhat varied in the parts which contribute to it, from the same parts in inhabitants of the air.

Here let us remark, that probably each tribe of animals has a different opinion of the nature of odours. If the vulture, were gratified only by what we esteem grateful, how could he purge the ground from carrion ? But while *that* excites him by its scent he freely relinquishes what others esteem. The smell of grass is, no doubt, most acceptable to animals that feed on grass, and that of fish, to such as are aquatic. I might observe that the smell of fish (and that of flesh, or other things) is itself no ill smell ; but at second hand, as in the fishy smell of certain birds, it is intolerable ; and prevents their feathers from being of any value for domestic purposes.

Smelling has its peculiar advantages, as well as pleasures ; the fragrance of early dawn, of new-mown hay, of blossoms, of fruit demonstrate its pleasure ; and most of us can vouch for its utility especially, when we recollect, that it warns us of the presence of fire, before it has made any considerable progress : thus we are enabled to detect and to check that devouring element, before it increases to a capacity of mischief. I for one frankly own, that I often trust to this sense ; that I by choice *inspect* my house in the dark, as best detective of fire by its light ; not without scenting cautiously what ever seems related to the effluvia arising from combustion. Many fortunate *preventions* have I known, or heard of, for which the parties were indebted to the sense of smelling. How happily is it for us, that the most destructive element has more than one harbinger, and that we have more than one mode of discovering it ! After this we must esteem it as indicating the want of proper reflection, when any one depreciates the sense of smelling : we admit, that it suffers vicissitudes, that it is not always to be trusted in cases of importance ; that it is one of the first to quit us, and many occasionally be dispensed with ; notwithstanding which, we find reason to suppose, that naturally it has considerable accuracy, and would generally direct us safely ; that it has peculiar pleasures and advantages, either in regard of health, or of medicine for restoration of health ;
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that it is highly friendly and effectual in its warnings of danger ; and that if we do not now enjoy it as we might, and as others do, it is no censure on the sense, but on what we prefer before it.

We close this discourse by repeating the remark, that the delights of nature would be nugatory, had we not respective means of enjoying them, that odours and perfumes, that incense and fragrance, were useless, and their existence without value, did we not possess the sense of smelling : but if among mankind are found so many modes of satisfaction that some may be spared, yet let us acknowledge, that among our fellow creatures there are many to whom this sense is peculiarly indispensable, who, without it, would linger out existence, and pine in the midst of plenty. Every thing is beautiful according to the purposes to which it is applied, and its aptitude to accomplish those purposes : but when necessary to support life, to detect evil, and to ward off misfortune, what is beautiful becomes also proportionably valuable and important, a character justly attributable to the sense of smelling.

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OF TASTING.

HAVING already reviewed several of the modes of sensation, we have anticipated much which is related to the subject of TASTING : When we say creatures are endowed with the faculty of digesting such or such food, and are distributed into classes according to the kinds of food by which they are supported, the inference was natural, that their taste also corresponded to these distinctions, and that the sense was exercised with equal variety. In recollecting therefore, that some creatures feed on living prey and delight in blood, that others prefer prey already dead, that to some fruit is most relishing, to others grain, to others grass, that fish is to some the most dainty repast, while there are those to whom nothing comes amiss, and who, without reluctance, devour whatever they can conquer : I say, when we recollect these instances, we need not engage in proof that tasting varies. Earth itself is thought to furnish maintenance to some creatures, and by its juices to yield them nutriment, while air has the reputation of supporting others, and water also, others.

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Amid so great a variety of relishes, tasting may be very accurate, yet very different; *that* may be agreeable to one, which is abominable to another, yet the sense may be equally exact in each.

The immediate objects of tasting are, such qualities as *sweet, sour, bitter, &c.* and in degrees, but not in extremes, each is pleasant. But this sense is, after a time, reconciled to what at first displeased it, and after such reconciliation, it acquires a fondness for its former aversion. Tasting, therefore, seems to be a versatile faculty, capable of adapting itself to contradictory circumstances. And, among mankind, it is well it is so, not only as a variety of gratifications would otherwise be unnoticed, but as change of aliment is greatly conducive to health. By this we do not deny the prejudices attending sudden changes, but only mean to support the propriety of that mixture and alternation, which nature offers in her different productions. While these are varied with the seasons, and adapted to their influences, their use seems to be distinctly suggested; especially, when we recollect, that many of them are transitory, that vegetable productions (especially) are but of limited duration, their season is quickly over, and their perfection scarcely attained ere it passes. We should observe also, that *correctors* to the influences of the seasons, are usually most liberally produced by nature in each season; herbs warming and chearing in winter, cooling fruits in summer: and this is much increased by the skill and industry of man, who keeps some till they are mellow, and improved from their verdant state; while others he gathers before too much ripeness has disposed them to lose their superior flavour, and their more estimable qualities.

To attempt any thing like an enumeration of what nature offers for human use, would extend this discourse to great length. Without instancing the variety belonging to the flesh of animals, in taste and in properties, the vegetable kingdom alone furnishes multiplied occasion of remark; for, beside those changes of aliment which vary with the seasons in temperate climates, there is correspondent provision made against the intemperance of tropical heats, and of polar colds. Beneath the Line, all manner of cooling fruits abound, and that refrigeration of which the air is destitute, they supply: witness limes, lemons, oranges, &c. of the sub-acid kind: melons, cucumbers, &c. whose degrees of coldness would be injurious, if but a little beyond what they are: two degrees colder, I think, would approach cucumbers to poisons. The heats of the tropics exalt the flavour of all productions capable of sustaining them; but
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these productions are for the most part extremely juicy: firmer kinds, as spices, can scarcely be called food, though they form a part of the ingredients in viands. If we advert to the grain of these countries, the principal is rice; and rice grows under water, or in situations where it has had, during part of its growth, plenty of that element. In those hot countries little animal flesh is used, and where health is regarded, little fermented spirituous beverages. Simple water for drink, simple pulse or herbs for food, prevail among the natives, who best understand the *finesses* required by their country.

Temperate climates exhibit the greatest variety; capable, by the assistance of art, of adding the richer productions of the Equator to their native stores; capable of transplanting from distant parts, whatever they furnish worthy attention. England is peculiarly an instance of this, if the popular tradition be true, that among apples, only crabs are truly British, and among plumbs, sloes. And we still retain the names of countries from whence we imported many of our fruits, as currants (*corinths*) from Corinth; damsons (*damascusons*) from Damascus; cherries (*cherfoneses*) from the Chersonese Peninsula; and many others, which suffer by removal from their native climes, Asia or Africa, and, lately, America.

It would afford much amusement to trace the progress of a particular taste, or of a valued fruit, from place to place. Here we should find it admired, because rare, and thought exquisite, because "we have nothing to compare with it:" there, being plentiful, it would be disregarded, and because procurable with little labour, would be thought scarce worth that little.

If we trace the progress of tasting among mankind, we should find them, at first, satisfied with the berries yielded by native bushes, then transplanting them into a richer soil, and more favourable exposure, studying to improve their flavour, to embody as it were their juices, to correct their astringency, and to increase their durability for stores; next, importing what foreign parts produced of superior value, adapting them to the soil and the climate, then grafting and mingling their qualities; so that after repeated removals and unions, they should become naturalized, and invalidate every attempt to determine their original stock.

It appears from this statement, that nature has done much for man, but has left him much to do for himself; she furnishes the means which he is to improve, offers the first rudiments which he is to complete, not only secures him from starving, but, by liberal variety, consults his appetite, yet never of her-

self produces what is perfect, so as to supersede his cultivation, or to pamper his idleness. If he wishes improvement, it is in his power—by industry; he shall find no ungrateful reluctance to second his endeavours, but his endeavours must precede the exertions of powers, which are latent, till he calls them to action. Can there be stronger proofs that the original destination of man was to attend a garden, to cultivate the earth? whose abilities were hid, till excited by a rational being, and varied by those unlimited combinations of which rationality is the parent. Nor am I without suspicion, that man has a peculiar genius for gardening; that a strong desire is by nature implanted in him for its enjoyments, and its productions; that it yields his purest pleasure, united to health and vigour, and is indeed his source of genuine delight. Hence persons long immured in towns retire to the country; hence rural occupations are so agreeable a relaxation; and hence a clear air and extensive prospects, or silent glades, so strongly influence the spirits and the passions. Are further arguments necessary, to prove that the true taste of mankind rather relates to productions of the vegetable than of the animal kingdom; and that, however now accustomed to the latter, it was not so in the beginning? Can there be stronger proofs, that self-maintenance is all that nature imposes on the individual: other powers of life being provided?

Tasting has certainly greater variety of pleasures connected with it in man than among animals; they feed on a limited and small number of articles; some are restricted to a single kind of tree or plant, some to a single leaf, others to a particular kind of prey, and these perhaps have the most sagacious relish. I suspect, that those which devour indiscriminately, have little or no exercise of tasting; and it may be, that the sense of smelling is in most creatures the more powerful sense: this directs them in the choice of food, and their tasting perhaps could do little more.

DAMPIER tells us in his voyages, that he never scrupled to eat fruits, &c. on which he observed the marks of birds having been pecking them; and he concluded in general, that what was fit for them was wholesome for man. This rule has exceptions; as appears in the instances of parrots, who sometimes feed on the manchineel apple. Monsr. BUFFON observes, that birds of prey prefer the same birds of game as man, and are fond of those of white flesh, which furnishes, says he, one analogy more between us and them. An adventurous Frenchman M. VAILLANT who lately travelled into Africa, was accompanied by a cock, and a monkey. The first, as watchful and of ap-
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proved fidelity, that he might sleep in security ; the second, as vigilant, that he might rise at day-break ; the third, that he might ascertain whether the fruits he found were edible ; concluding, that if the monkey ate them, he might safely follow his example, but that if he rejected them they were pernicious. The analogy between the monkey tribes and man in shape, &c. seems to insinuate, that what was good for one, could hardly be hurtful to the other ; and in point of instinct, the advantage is with pug, as no doubt it is with animals in general. Even a hog, though esteemed a voracious glutton, has too much taste to eat indiscriminately all the plants offered him ; but, I think, out of 250 he rejects 100. This choice belongs to most, if not to all grass-eaters ; for, as nature exhibits the utmost variety among vegetables, did all animals choose alike, those refused would multiply to excess. The same may be said of aquatic birds, which, among the numerous tribes of fish, have doubtless their favourites ; and of quadrupeds, which, though they feed on many kinds, are peculiarly fond of some ; as we see dogs, if not severely pressed by hunger, seldom eat rats ; and cats prefer the mouse, though they feed on other creatures. Animals, like ourselves, may be depraved in their taste ; we have heard of a horse that ate oysters ; and of Diomed, king of Thrace, who fed his horses on flesh, and was at last devoured by them ; a fate he well merited ! Savage beasts also eat others of their own species, as wolves, jackalls, &c. and among depraved or impetuous taste, perhaps we may include the strange disposition of some creatures to eat their own young. As to depraved taste, in the instances of green-sickness, &c. that is disorder of more than the mere seat of the sense.

Tasting does not always determine the salubrity, or insalubrity of food : much that is sweet is hurtful ; but in general, what is offensive to the taste is properly rejected. We cannot *absolutely* trust to our smell, or our taste, when they pronounce in favour of what they examine, but what they dislike is usually worthless if not dangerous.

We said, that the sense of smelling had sustained in man great injury, by artificial scents and provocatives ; artifice has had effects at least equally injurious on tasting. Epicurism has depraved the sense, and those who cannot relish a meal without ingredients of high flavour, and of contradictory poignancy, not only injure their health by embarrassing the operations of nature to promote it, but must be considered as persons of the most depraved appetites ; as farthest departed from the standard of what is beneficial, and as indulging a transitory gratification, at the expence

pence of permanent satisfaction. Health is the chief end of nature when the senses of smelling and tasting are in their full powers; the smell excites the taste to enjoyment, or prepares it for disgust; and disgust keeps clear of what might prove prejudicial to the functions of life. But, if taste be excited by smell, there is yet a chance that when itself is engaged in judging, it may rectify the errors of the former; as well as determine on subjects, whose scents are neither attractive nor repulsive.

The immediate seat of tasting is the palate: the tongue seems to partake of the sense, but not in all cases. The tip of the tongue dipped into sugar, will not communicate the idea of sweetness till it has touched the palate. Yet by some substances the tongue is affected; hellebore affects the inner part of the tongue, mezerion the throat, and peppermint drops laid, till they dissolve, on the tongue, may be tasted. It seems, indeed, that moisture is necessary to tasting; and must either be furnished by the subject to be tasted, or by the *saliva*. For when both the subject and the tongue are dry, no taste whatever ensues. A mere sensation of feeling is all which occurs.

Tasting, like our other senses, is performed by nerves, spread to receive impressions; these are distributed over the tongue and palate, and fill the *villi* (little rising processes) of those parts. These *villi* are varied; and (probably) among creatures possess different powers, so that what to one kind seems pleasant, to others is disagreeable. Some persons have endeavoured to account for taste, by considering it merely as a nicer kind of touch: pointed bodies, say they, applied to these *villi*, excite a powerful sensation, — these are salt: other bodies being rounder, slide smoothly along the *villi*, — these are sweet. These principles may be true, or they may be erroneous.

Tasting varies with the progress of life: children abounding in moisture, taste every thing much sooner, even though its relish be feeble, than grown persons do; to which effect, no doubt, contributes the yet comparative purity of their organs, not vitiated by the perplexing variety, or the piquant strength, of what they have been accustomed to. Age, on the contrary, is not without difficulty excited to the enjoyments of tasting, especially where intemperance has injured the organs.

Thus have we noticed the principles of the sense of tasting: observing, that it differs in its choice among animals, and determines them to the nature of their food; that its versatility accommodates itself to what was once its aversion; that nature has amply provided for gratifying its variety, and directing it to beneficial effects; that it excites human industry, and seems designed for

for that purpose. We have observed also, the seat of this sense, its powers, and the changes it suffers by custom, and by the course of years. We remark on the whole, that to prescribe rules for its direction is impossible: what is pleasing to one offends another, and the liberty of private judgment is here at least inviolable. It also results that as tasting was intended as a guide to healthy nutriment, every depravation of it is attended with danger, every intemperance is not only a risque for the present time but for futurity; lest it should rise into habit, and, if confirmed, be extremely detrimental. The great lesson taught by nature, is MODERATION: all beyond tends to enfeebled powers, to absolute loss and imbecility: *so much* is fit and proper, *so much* may be pleasant, *so much* may be endured. Nature revolts if further provoked, and punishes by depravity and deprivation, those who stimulate her powers to excess.

We have now discussed those principles, which we esteem ourselves justified in considering as indispensable to life: abstract any one of them, we sensibly feel its absence, though not equally the absence of each.

It is not to be supposed, that, in offering *general principles*, we should be able to include *every particular*; after all possible care, much that is intricate will elude our distinctions, much that is novel will apparently controvert received opinions, much that is rare and extraordinary will perplex our judgments, though formed on the soundest principles, and supported by the analogy of numerous and well-authenticated facts.—In the celestial expanse of stars, observation has discovered many, and endeavoured their arrangement; the *chief* may be arranged; these form the signs of the Zodiac, or compose the constellations of the heavens; but after much ingenuity and great variety of figures, many remain *unformed*; many are too small to be included, many are but lately known, as instruments have been perfected, and where formerly we reckoned three thousand, now (by Mr. HERSCHELL) is reckoned *thirty thousand*: Such is the state of general principles when referring to the extent of nature's works. But as these new stars are, either *in* or *near*, adopted constellations, and may be considered as related to them, so whatever among the tribes of nature is singular and wonderful, rare and perplexing, as our knowledge increases may be referred to some or other of those principles which have engaged us. For, many things are wonderful, only because we see them but *partially*; when

when all their connections are known, our wonder ceases: As we admire those instruments whose powers are hidden, but when acquainted with all their machinery, our surprise, at least, is moderated. Nay, with regard to most constructions of human art familiarity with them lessens our esteem or applause:—because we perceive their limits, and discover their imperfections; we find many awkwardnesses of combination, and much contrivance that is misplaced. This constitutes a striking difference between the productions of creatures like ourselves, and those of Omniscient Wisdom;—which ever excite fresh admiration, as we become more intimate with them, and open thousands of excellencies, to the discernment of those who, by attentive diligence, have acquired a worthiness of such discoveries.

We cannot direct one cause to many effects, like nature; nor foresee as well benefits as inconveniencies, at a remote distance; we cannot force seeming evils to advance substantial good, make destruction the parent of population, make barrenness contribute to plenty, and revive disfigured beauties with heightened delight; we cannot unite the snow-topp'd summit and volcanic entrails, in the same mountain, thereby engaging heights and spots precluded from general use to promote general advantage; we cannot direct the mineral exhalations, and their noxious effluvia, spreading desolation around their seats, to produce the means of fertility; we cannot rule the heaving earth, and regulate its convulsive struggles.—If unable to controul inanimate matter; how should we comprehend the springs of vitality, or trace to their origin its various modes? How should we determine its degrees,—its maintenance—and support? The scale of life embarrasses our conception, the distributions of life our judgment; the members of life, their actions, their offices, their principles, perplex us, even in their lower stages, as exhibited among creatures our inferiors. And if we advert to ourselves, if we investigate rationality, the properties and the effects of mental powers, we are bewildered and confused, we hesitate and falter, we hint, we imagine, we suppose, we guess, but we determine nothing: arguments lead where opinion fears to follow; and we may yet appropriate the precept, “know thyself.” Nevertheless, we trace, if not principles, yet their action; if we cannot demonstrate the sensorium, we are certain of the senses; and however we may be ignorant of their transmitted effects, their exercise is personally evident. Surely we feel, and see, and hear, and smell, and taste: we cannot, while in our senses, question their natures. We know also, that our senses act by the nerves; that if these be absent, or injured, if

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weakened or embarrassed, if too tight or too lax, sensation suffers. If we perceive not *how* these nerves affect the brain, or are themselves affected, at least we discover wonderful contrivance, in their appointments, their situations, their combinations, their precise fitness for the offices wherein they are engaged, their happy arrangements, and their appropriate peculiarities. In possessing such variety, we notice our favoured situation above creatures destitute of several, and we infer, that as they are incompetent to our share of knowledge, superior beings may possess superior means of information; circumstances that escape us may be familiar to them, circumstances that perplex us, may lie open to their instant inspection; they may easily unravel intricacies which bewilder our reasonings, and embarrass our conjectures. Are then creatures below us less happy, creatures above us more happy, than ourselves? No: happiness arises from filling up with propriety that station in which we are placed by Divine Providence, whether exalted or abased, whether splendid or obscure, whether of example or of imitation, *that* post is appointed us by Infinite Wisdom, who never determines rashly on stations or their occupiers. Should the ear refuse its office, because it is not privileged in point of distance like the eye; should the palate refuse to taste, or the nose to smell, because taste or smell is restricted to determinate parts, not general over the person, what confusion would ensue! Should we repine at our portion of senses, because creatures our inferiors enjoy greater degrees, what unthankfulness would that demonstrate! To neglect what we have, out of envy at what we have not, were at once ingratitude and folly.

O for a grateful heart, a heart sensible of the obligations arising from constant reception of benefits, from constant vigilance for our welfare, and constant attention to our interests, in that great Being, who, if distance might include neglect, never need think of us, never need direct toward us one complacent smile, one beam of mercy! Who yet notwithstanding our distance, and unworthiness, our negligence and inattention, daily becomes our benefactor, and "in whom we live, and move, and have our being."

OBSERVATIONS ON THE PLATES.

THE EYE.

No I. Shews the several refractions of the rays of light, in order to their acquiring a true and exact focus.

The outer coat of the eye is termed the *sclerotica*; adjoining to that is the *choroides*, which is lined by the *retina*. *B c d B*, is the transparent projecting part of the *sclerotica* called the *cornea*; between which and *C C* (the *crystalline humor*) is placed the *aqueous humor*. *D D* the *vitreous humor*, occupying the remaining internal space of the eye. *N* the *optic nerve*, inserted laterally, leading to the brain. *o o* the pupil.

A, is a ray which, striking the eye precisely centrally, needs no refraction in its passage to the bottom of the eye.

a b, are two parallel rays, striking the eye in *c d* (the *cornea*), whose refractive powers would divert them from their direct course, to a focus beyond the extent of the eye (as *F 1*), were no other medium interposed: but, in their passage to *F 1*, they impinge on (*C C*) the *crystalline humor*, and by this are again converged to a nearer focus (*F 2*): But as this also is beyond the limits of the organ, they are, in passing out of *C C* into the *vitreous humor*, again converged, and fall exactly on the nervous expansion of the *retina*, at a third focus (*F 3*), there producing perfect vision.

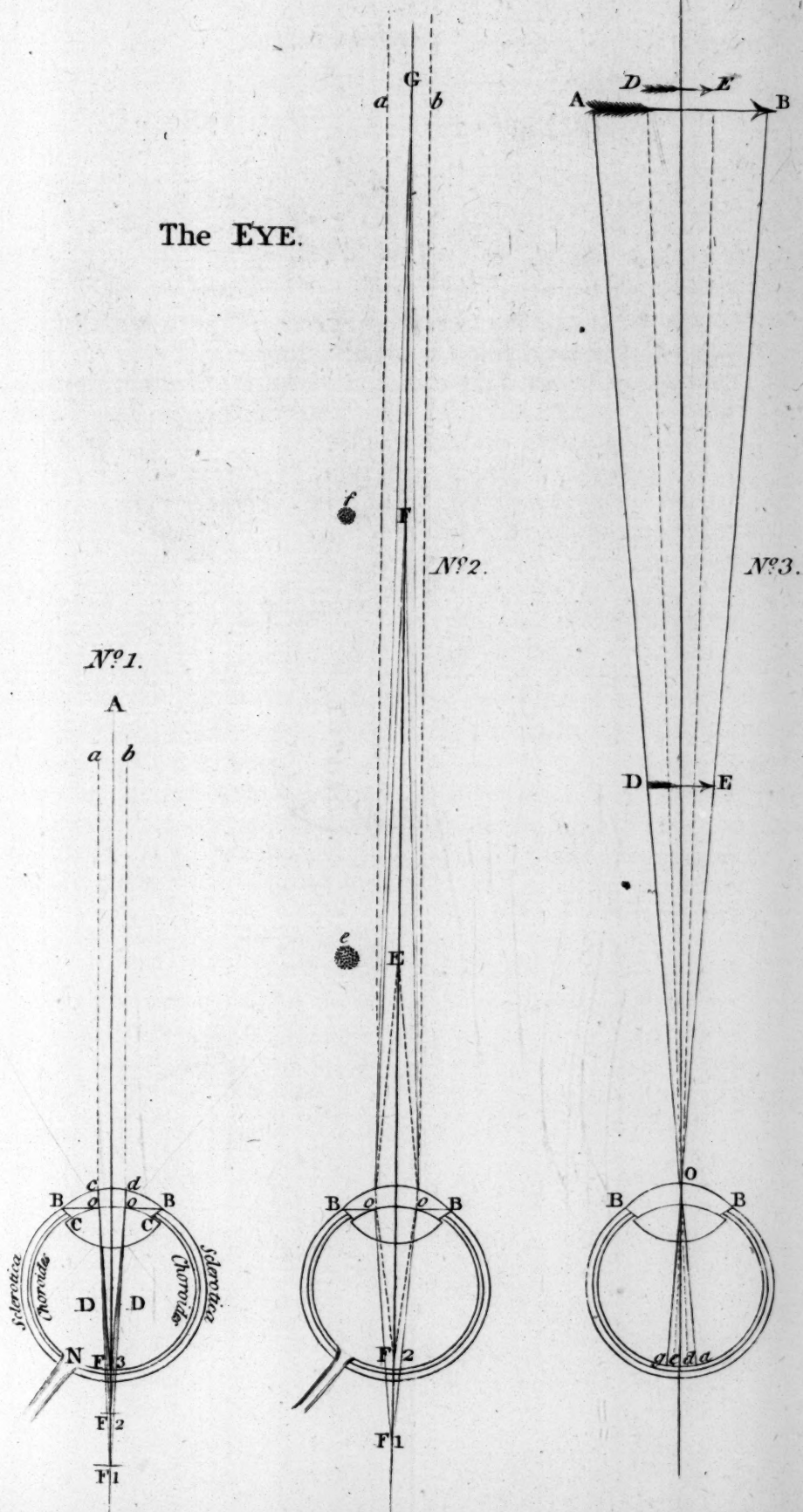
No II. shews the imperfection attending vision, when the focus is formed *behind* or *before* the *retina*.

If an object (*E*) be too near the eye when viewed, the rays proceeding from it, will after entering *o o* and suffering the refractions as before, be converged to a point *beyond* the true focus (as *F 1*), consequently, *at* the true focus, they may depict some confused image (as *e*), but not a just representation. The distance *F* is nearer the truth, as appears by *f*. At the distance *G*, the rays become so nearly parallel, that they fall justly on the *retina*.

If the state of the humors in the eye be such as to converge the rays to a focus *before* they reach the *retina*, dimness of sight equally takes place. Both these disorders occur; the former requiring *convex* lens glasses, the latter requiring *concave* lens glasses, to correct their defects.

No.

The EYE.



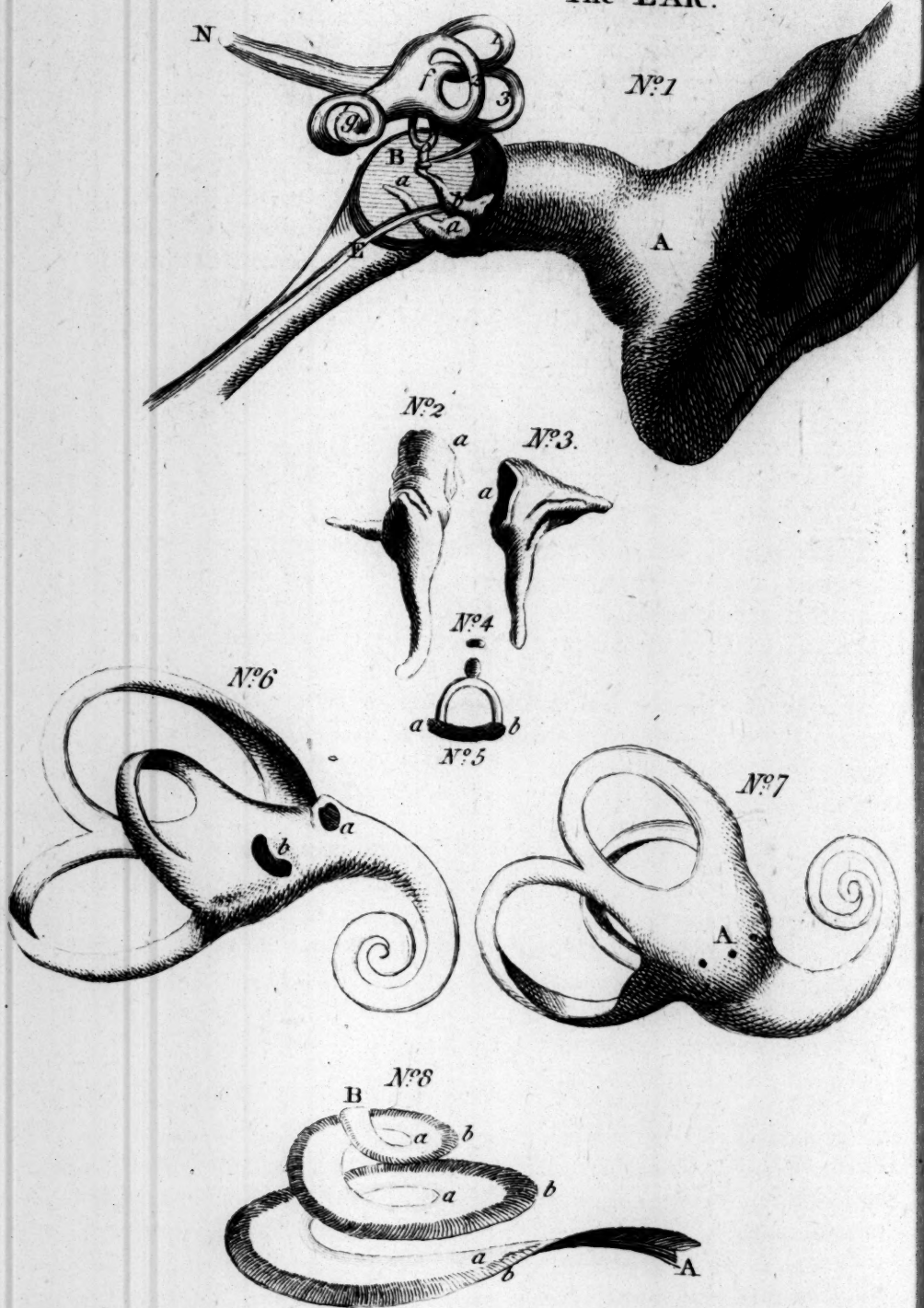


100. 3. 41.

1. 1.



The EAR.



No. III. shews the reason of the diminution of objects in size, by distance.

A G and D E being seen by the eye in the same line, after they have suffered equal refractions, depict on the retina the object $g a$; or occupy correspondent equal space on the retina: the angle $g O a$ being equal to the angle $A O G$. Whereas D E, removed to the distance of A G (as $D E$), occupies only the space d , consequently appears so much smaller to the eye which inspects it. But (while otherwise ignorant) the eye would never determine the proportionate dimensions of D E and A G; or their relative distances, being deceived by the similarity of their angles.

.....

THE EAR.

THE construction of the parts adapted to hearing, is so complex and intericate, that it is extremely difficult, to convey just ideas of their situations and uses, either by description or representation: we have therefore enlarged the parts separately, as well as shewn them united.

No. I. A, the external auditory passage (whose commencement at the ear is too well known to need explanation), tracing which, internally, we come to B (the *membrana tympani*, or drum of the ear) which is an expansion almost circular, tightened or relaxed, by $a a$ (the *malleus* or hammer), which rests on it about its middle. The malleus is at its head articulate to b (the *incus* or anvil), which, at its other part, joins a very small bone the *orbicularis*, and this the *stapes* or stirrup c , whose office is to close, by its other end, the orifice of the *foramen ovale* in the *vestibulum*. f is the vestibulum, g the *cochlea*; 1, 2, 3, the semicircular canals; N the auditory nerve, entering the vestibulum and lining it throughout; E the Eustachian tube, which communicates to the mouth.

It should be remembered, that these parts are surrounded on all sides by the bone of the skull, consequently are hollowed out of it; but that covering being supposed to be absent in this representation, no regard can be had to the *bearings* of these parts in relation to it.

No 2, is the bone *malleus* at large, shewing many *rifings*, &c. whereby it is held more securely in its place. a , its head which articulates

articulates into the hollow, *a*, of No. 3 (the incus), accurately fitting its irregularities. No. 4. is the orbicularis, which unites to the stapes, No. 5, whose termination, *a b*, covers the foramen ovale of the vestibulum.

No. 6. is the vestibulum at large; seen on that side which shews the *fenestra rotunda* (*a*), and the *foramen ovale* (*b*); which last is shut by the stapes.

No. 7 the vestibulum, seen on that side which shews the perforations, *A*, whereat the auditory nerve enters the vestibulum, in order to line its inside *throughout*.

No. 8 shews the spiral division of the *cochlea*; part appearing bony, part membranaceous and nervous in texture, whose cords lie in the direction expressed by the strokes; these varying in length so greatly, and with such regularity, are adapted to receive impressions of all degrees or tones of sound.

The course of sound is, from its entering the ear to the membrana tympani, [but if the sound enters through the mouth (as that of a watch held between the teeth), then it is through the Eustachian tube] into the cavity of the drum; where, exciting the small bones there situated, it is transmitted into the vestibulum, which is the immediate seat of hearing, partly through the *fenestra rotunda*, partly through the foramen ovale, if the stapes be pulled away from it.



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ASTRONOMY.

(157)

THE
GENERAL GENTEE PRECEPTOR.

.....
P A R T VI.

BEING
INTRODUCTORY
PRINCIPLES OF
A S T R O N O M Y.

.....
OF THE SUN.

.....

“ O thou that with surpassing glory crown'd,
Look'ſt from thy ſole dominion like the God
Of this new world ; at whoſe fight all the ſtars
Hide their diminiſhed heads : to thee I call,
But with no friendly voice, and add thy name,
O SUN! to tell thee how I hate thy beams,
That bring to my remembrance from what ſtate
I fell,—how glorious once above thy ſphere,
Till pride and worſe ambition threw me down.”

Paradiſe Loſt, Book IV.

SUCH, ſays our immortal Poet, MILTON, was the addreſs of
the malignant ſpirit to our ſplendid luminary ; of whoſe bene-
ficial effects, we entertain the moſt honourable opinion.

Y

If

If idolatrous worship *may* be in any degree palliated, that paid to the Sun seems to have had the greatest pretences to reason: without his irradiating beams, what were the globe we inhabit, but a cheerless void? without his invigorating heat, it were an idle waste. How melancholy would all mankind become, could they believe that at such a time his splendour would finally cease, or that he would then set to rise no more!

As it is, and under no such apprehensions, we behold with regret the Sun's departure; and were not his absence the time for repose, and were not repose indispensable to our wearied nature, we should never willingly forego the light of the Sun: justly, therefore, may he claim the first engagement of our attention.

The Sun is distinguished from every object around us, by his LIGHT; this is his first and strongest distinction, and is so necessary, and pleasant to us, that we pity those eyes that never have beheld it.

Is it inquired, of what is this source of light composed? Before we attempt an answer, we must premise, (1) that we have nothing on earth, in any degree, comparable to it, whereby to determine its properties by comparison; for as our earth is an opaque body, void of native light, it affords no applicable example. (2) What we call fire, or light, i. e. what fire or light we on earth may be supposed to possess, is not elementary, but gross, terrestrial, and impure, even after we have made every allowance and distinction between fuel and fire. It follows therefore, (3) that we can only conjecture on this subject, and support our conjectures by the analogy of such substances, or circumstances, as come under our examination.

We may conceive of any matter whatever as either solid, or fluid. Solidity, is such a fixity of parts, as does not permit the motion of one over others. We cannot, in pushing a solid body, push what parts of it we please, but, of necessity, we push from us the whole of such a body; whereas, we may roll over and over, may displace and remove, any of the parts of a fluid: For instance, we may agitate the surface of water without moving the bottom; or may furrow one part of it, while a distant part remains tranquil. By the bye, we are apt, when we instance a fluid, to suggest the idea of water, because that fluid is our most intimate acquaintance: but we ought to recollect that some fluids are of much greater weight and compactness (*substance shall I call it?*) than water; certain chymical oils we know are so; quicksilver, or mercury is so, fourteen times heavier than water; and continuing this progress, we may easily conceive of a fluid

extremely

extremely dense and substantial, and yet permitting a motion of a part, or parts, of its quantity, without disturbing the whole; whereby it will ever be distinguished from a solid.

Of some such fluid the Sun has been presumed to be composed; a close, adhesive fluid of light; a *consolidated* fluid is, I acknowledge, an improper expression, yet it may serve to describe a fluid so compressed, so united, as to leave scarce any vacancy between its component particles; consequently, the same extent of space may contain a very much greater number of particles, than if they were looser, more distant, or separate, from each other; we say at present ten times as many; consequently also, if any given number of particles be supposed to quit this incorporate assemblage, in a given time, it will be ten times as long before such a compressed body is exhausted.

A fluid is more easily acted upon than a solid, its parts are more easily separable, and, when separated, are more divergent. Water is easily acted on; the very passage of the air over it, deprives water of some of its particles, and its vapours spread every way, much further than dust, or any similar substance, flies from a solid body. The fluid, therefore, of which the Sun is composed, is adapted to *give off* its particles; but, to increase this disposition of the solar superficies to *give off* its particles, and to impel these particles with vigour sufficient to quit that body, to which they naturally adhere, some active and vigorous impulse must *drive* them from their native abode: and this impulse we find in a *ROTATION of the solar orb on its proper axis*.

Though our visual powers may be well adapted to the globe we inhabit, yet, we must not expect to find them equal to the examination of distant worlds. It is true, the outline of the Sun seems *round*; yet, for aught we know, that part of him, which more immediately faces us, might be flat: he might resemble a large dish set at a distance, and be merely a flat body of a certain thickness, without any revolutionary motion. I freely confess, I think, that had he been so, we should have had little occasion to admire his resplendence; much more probably we should scarce have seen him. But, if we suppose him a globe, and revolving on his axis, we suppose a power which causes incessant agitation and motion among his exterior particles especially, and which by its constant and perpetual activity, *whirls* his luminous beams in every direction around him.

Of all matter hitherto known, light is composed of the *smallest* particles; and of all globes hitherto examined, the sun is immensely the largest, being 793,000 miles in diameter, and his superficial contents 10,000 times the surface of the earth. The rapid

rapid revolution of a globe so prodigious, must have most powerful effect on particles so diminutive ; it must shoot them throughout space, and nothing can obstruct their progress, but such opaque and solid bodies as forbid their penetration. Yet from such bodies they rebound, diverging every way. By such reflected light we see the moon, and the planets.

The MAGNITUDE of the sun is closely connected with his SITUATION *in the system* : and we ought to observe that according to the advances of science, the magnitude of this luminary is calculated proportionably greater than formerly ; which proves, not that former principles were erroneous, but that they were not perfected, by such accuracy, and advantages, as later times possess.

The solid bulk of the sun is estimated at one million times the solid bulk of the earth ; his surface, at ten thousand times the surface of the earth ; his diameter, seven hundred ninety-three thousand miles.—Dimensions worthy admiration ! It seems at first sight, as if here was a waste, a redundancy : might not a sun of less magnitude have equally dispensed its beams, and excited heat, to equal benefit. Light and heat a sun of smaller magnitude *might* have communicated ; but it would not therefore have been to equal benefit. Witness what we so lately remarked of the impulse of light ; smaller dimensions must imply smaller power. Besides this, modern discovery has demonstrated, that all large bodies attract smaller ; that all small bodies gravitate toward larger ; that the more are the contents of a large body (*i. e.* the more compact, close, and dense its particles), the greater is its attractive power ; it follows, that a sun of diminished magnitude would have been proportionably weakened in its effects on surrounding bodies. Were the sun suddenly shrunk to the dimensions of our earth, the order of the heavens would cease, the sun would be drawn from his station, and the larger bodies around him would attract him toward themselves. If we add the supposition, that our earth was suddenly enlarged to the dimensions of the sun, then it would become the centre of the system, and merely by its magnitude would attract every revolving planet,

It was necessary therefore, that the sun should be immensely large, that his dimensions might exclude every rival, that he might maintain his station immovably, and that the influence, of his attraction might extend to the very extremity of the system. Reason favours the supposition, that the largest and most attractive body should be placed in the centre ; around which the smaller must circulate ; and here the source of light seems most properly

to be expected. In fact, the sun is the centre of the system : and around him circulate the planets, and their attendants (one of these planets is our earth) ; all at such regular distances from him as counterbalance the effect of solar attraction, which constantly weakens, as distance increases. From the sun then, we calculate the distance of his attendant planets.

Thus we have conjectured, at the nature of the sun's body, at his globular form, at his immense magnitude, at his central station : we support some of these conjectures, by remarking that many SPOTS have occasionally been observed on his surface. I remember a baker's man exclaiming, "Master! Master! do come and look, there's a hole in the sun;" "Aye, John, that I will," replied the master, "what's on t'other side?" The spot which occasioned the outcry, was surely large enough, for I remember seeing it with my naked eye, and that distinctly : it was (really) at least five times the surface of the earth. Solar spots are seldom so large as this was ; their magnitudes and their forms vary ; and sometimes even while subject to observation.

Most of the spots consist of a deep black centre, surrounded by a dusky cloud, whereof the inner skirts, next the black, are somewhat brighter than the outskirts ; they change their shapes, somewhat like our own clouds, but they take longer time about it, sometimes a few hours, sometimes days ; sometimes a spot breaks into two or three ; sometimes two or three unite into one ; sometimes they are very numerous on the body of the sun ; sometimes none appear for a considerable time. But the principal circumstance attending them, is their motion, over the disk of the sun. They enter the sun on his east side, and gradually crossing his whole face, they go off on his west side. Now, if there be twenty or thirty of these spots at once, and all follow the same motion from east to west, it implies very strongly, that such is the motion of the sun's body. Indeed they were the first to demonstrate that the sun has such a motion, and also that he is a globe, and not flat.

In looking at any flat object, across which a body moves with uniform velocity, you see it move *straight* ; moreover, it seems in every part of its course to move with equal speed, but the same object passing over a globe, seems to move quicker on the protuberant part of the globe, that most directly opposed to the spectator, and slower toward the sides, or extremities. Exactly so are the solar spots ; they advance slowly, and increase in their apparent swiftness, but their swiftness decreases as they advance to the edge of the sun's disk. The solar spots appear also changed in their forms, becoming narrower as they approach the edge of the solar disk, till at last they become very thin, and disappear.

It is natural to suppose that these spots move in the regular course of the rotation of the solar orb, *that* is, no doubt, perpendicular to his axis; had they moved vertically, they would have proved his axis to be horizontal; had they moved horizontally, they would have proved his axis to be vertical; but as their course is somewhat inclined, and only *nearly* horizontal, they prove the sun's axis to be—not perpendicular, but inclined to the plane of the ecliptic, above seven degrees and an half.

There are various opinions respecting the nature and formation of the solar spots; some have suggested, that the sun has an internal nucleus, opaque, mountainous, and uneven, like our earth, which being covered over with a fiery luminous fluid, its ebbing or flowing may occasionally expose the tops of the mountains, &c. adjacent, which appear like black spots. Others think that the sun's body may contain volcanoes, which ejecting from time to time vast quantities of bituminous substances, they, and their smoke, &c. occasion these spots; that as these volcanoes exhaust themselves, their smoke diminishes, and being fired by the sun, becomes brighter than the parts around them: for it is observed, that the dark spots termed *maculae*, are usually succeeded by extraordinary splendour in the same parts, which splendid spots are termed *faculae*. Others guess, that in the fiery fluid are immersed huge opaque bodies of irregular shapes, which rising to the surface from time to time, form spots; while others suppose, that as in melted metals, the scum rises to the top; so the fluid of solar light, being in perpetual agitation, raises the grosser parts in various forms, which at length it dissipates, or re-absorbs.

There is great reason to conclude, that the sun is encompassed with an ATMOSPHERE of light; either the ether which immediately surrounds his body, heated so highly as to become luminous, or fiery particles emitted from him, and retained near him by his attractive power. We must also remember, not only that there is of necessity a much greater number of particles around him, before they are diverged into the vast expanse; but also that in our inspection of this luminary, his rays cannot but be *fore-shortened*, and consequently more sensible the nearer they are to his body. This seems to be a very rational and well supported opinion.

The *face of the sun* when clear of spots, seen by the naked eye through a smoked or coloured glass, or through the vapours of the horizon, (the effect of these mediums is only to moderate the brightness of his rays, and permit the eye to bear the sight of the luminary) seems equally refulgent throughout; but through a telescope, the middle or protuberance of the disk, from whence the

the light reaches us almost directly, seems the most splendid: as it is natural to expect from a globe.

Does the sun diminish? Is he perpetually supplying light, and dispensing that important fluid without restitution? if so, does he not waste? Perhaps not; consider first the surprising smallness of the particles of light; how many myriads may be compressed into an inch space of *solid* light, we know not; next consider the immense superficies of the solar orb; if such a globe were diminished in depth one mile, or ten miles, or much more, so trivial is this proportion to the globe itself, that no possible observations could detect the loss. Perhaps also, there is no matter really *annihilated*, there may be some circulation of this fluid, which having performed its office throughout the expanse, may be returned to its celestial origin. Is it impossible that it should be interchanged by distant suns?

The proverb says, "The sun cannot be looked on stedfastly;" and we must acknowledge, that our visual powers are unable to inspect this luminary; but our intellectual faculties, which elevate humanity above its fellow-creatures, appear to great advantage in those contrivances, and reasonings, by which we investigate such immensely distant and wonderful objects. Our senses are confined, but our ideas are free; our conceptions range without control over the universe itself: and it is our own faults if they return not with treasures of wisdom.

The object we have been contemplating may well contribute an ample share to such treasures. The Sun is our constant friend, not merely paying us occasional, or ceremonial visits, but perpetually exerting his good offices; substantial benefits accompany his presence: the whole creation awaits his approach, and daily welcomes his return; his favours are impartial, free, liberal, distributing unreserved bounty to every atom of life: if at any time he is obscured from us, it is by our own clouds; if his lustre is ever veiled, it is by terrestrial vapors; the fault lies not in him, but in ourselves, and we will not suffer such interruptions to prevent our gratitude.

Gratitude is the effect of a just sense of favours received; if we undervalue them, we are so far ungrateful, if we overvalue them we are so far verging toward idolatry. If we distinguish not the real source of our benefits, our gratitude is misplaced; and this very subject is a proof what dangers arise from a mistake so unhappy, since the sun himself is a servant, not the Master, a creature, not the Creator. Yet there is something more amiable in acknowledging benefits received, though we err as to their author, than in being insensible of them, and never raising an adoring eye

to the Heavens which furnish them ! here we pity error, but there we detest ingratitude : and while we wish to be equally distant from both, and while mis-directed superstition cannot be sufficiently exploded, I think we may safely prefer it to brutal and thankless atheism.

We began this discourse by saying, if idolatry might be palliated, it must be in worship of the sun ; and true it is, that to the dazzled eyes of mortals, the Sun in many respects, if not divine, yet seems a fit type of divinity. But we shall find a comparison, however slight, infinitely to the disadvantage of the luminous orb. The sun has *spots* ; but “ God is light ; and in him is NO DARKNESS AT ALL.” If we cannot bear the light of the sun, but must interpose denser mediums to moderate his rays, what wonder no flesh can see HIS face “ who dwells in light inaccessible and full of glory ? ” The sun too has his inclination, and his revolutions, but “ with the Father of lights is no variableness, nor shadow “ of turning ; ” no change, no vicissitude. I confess the magnitude of the solar orb is great ; he shoots his rays far, very far, but they diminish in power and effect, by distance : whereas Deity is omnipresent, omnipotent, and his effulgence is universal and undiminished. Nor let the sun boast of perpetuity ; time was, when he shed no ray on any gladdened world ; time shall return, when his services shall be dismissed, and his lamp extinguished. This may be distant, very distant, but when ten thousand times ten thousand suns, his successors, shall like him have expired in darkness, Deity shall be no nearer termination, ever, as before, perpetual ; the only just object of veneration, of reverence, and of love !

OF THE MOON.

IN our evening walks we are often led to observe what pleasing advantages we derive from that fair planet which is the subject of our present discourse : to remark the cool silvery beam, and the sober resplendence, shed by our attendant satellite ; whose highest degree of brightness is no ill substitute for the sun himself ; and indeed after the sultry heat of an autumnal day, we enjoy no less the rising of the moon, than after the season of repose, we enjoy the beams of morning.

Is it not laudable to enquire the regulations, and the properties of this gentle planet ? is it not natural to wish for information
with

with regard to its changes, of which we are spectators? with regard to its influences, which we know are considerable?

The moon is at no very great DISTANCE from the earth, as distances are found among heavenly bodies; about 240,000 miles; she revolves round the earth from west to east, in about twenty-seven days, which is called a *periodical month*; and in every part of her orbit she presents a different aspect to our view.

If the moon was a true luminary, possessing native light, we should never perceive in her any diversity of form; but as she shines by light received from the sun, and reflected by her surface, it follows, that according to the situation of the beholder with respect to her illuminated parts, he will behold more or less of her reflected beams: for only one half of a globe can be enlightened at one time.

The principle is familiarised by a simple experiment. set a candle at the further end of a table; hold a watch *between* the light and the spectator, the dial-plate turned to the candle: now in this situation we can neither see the dial-plate, nor any light reflected from it, but by moving the watch a little to the left, the dial-plate comes in sight; and the further it is moved to the left (preserving its circular motion round the spectator) the more of the dial-plate becomes visible, till at length having got half through the revolution, the dial-plate is exactly opposite to the spectator, and is visible distinctly and entirely.

Observe, that at first, the earth (the spectator), and the moon (the watch), were in a direct line with the sun, (the candle), the moon being *between* the other two; but now the moon and the earth are again in a direct line with the sun, but the spectator is between the other two, (this is termed *opposition*.) Thus, at full moon, in what quarter of the heavens is the sun?—diametrically opposite to the moon. There remains now only to continue the course of (the watch), the moon round (the spectator), the earth, to complete a revolution, and bring her again to the station she quitted.

This would be a just representation of these planets, were the earth always at rest; but while the moon has been engaged in her course, the earth also, having a course of her own, has advanced during one lunar revolution (or month) in her proper orbit, and the moon must prolong her progress, in order to come again exactly into a direct line between the sun and the earth, from which *conjunction*, she is to begin her course anew. This additional time is upwards of two days, and five hours, making in the whole twenty-nine days, twelve hours, and forty-four minutes, which is termed a *synodical month*.

These

These bodies being now in a straight line, may explain the nature of ECLIPSES. The line described by the moon in her course, does not always coincide with the line of the earth's motion, but is sometimes higher, sometimes lower; and agrees with it only now and then, crossing it in certain parts in most of its revolutions. If the course of the moon be *higher* than the plane of the earth's motion, it cannot intercept the light of the sun from the earth, (which constitutes, an eclipse of the sun); for the rays of the sun pass *under* it; or if, when between the sun and the earth, it be *lower* than the plane of the earth's motion, it hides no part of the sun, but the rays of the sun pass *over* it: but when between the sun and the earth, the moon is in that part of her orbit which coincides with the plane of the earth's motion, then she is *bonâ fide* interposed in a direct line, between the sun and the earth, and in consequence, the beams of the sun passing toward the earth are intercepted by the moon, and the earth is deprived of them: in other words, the shadow of the moon falls upon the earth. This constitutes a *SOLAR eclipse*.

An eclipse of the moon, it is evident, cannot happen in this situation, which is that of what we call new moon; her unilluminated face being turned toward the earth; nor can it happen when she has performed a quarter of her course, for then she is not in a direct line with the sun and the earth; at the full moon only, can this event happen.

As the path of the moon is not always coincident with that of the earth, she enjoys at this period much the same advantages as we have observed the earth had enjoyed, *i. e.* that when her course is *higher* than the earth's, the rays of the sun reach her, by passing *over* the earth; and when her course is *lower* than the earth's, they reach her by passing *under* it: but when the two courses truly coincide, the earth receives the light of the sun, and intercepts those beams which were passing towards her. In consequence, having no light in herself, she ceases to shine, in such proportion, as the earth has deprived her of light; in other words, as the shadow of the earth falls upon her.

Such are the elementary principles of that *phænomenon*, which excites terror in the mind of ignorance; which has been dreaded as an evil omen, has sunk the hearts of the most valiant, and has weakened the spirits of the most magnanimous! Nevertheless the celebrated eclipse of the sun, foretold in the infancy of Astronomy, by THALES the Ionian (*ante* A. D. 603), which happened during a battle between the armies of Alyattes king of Lydia, and Cyaxares the Median, being regarded by both parties as an evil omen, it suspended the engagement, and was followed by a peace.

This

This phenomenon, once generally dreaded, and dreaded still among the unenlightened nations of the earth, yields us rational entertainment; such is the difference between knowledge and ignorance! *we* look out for an eclipse, and anticipate the satisfaction of the sight, while the savage shrinks from the awful appearance, or clatters every instrument capable of noise, that he may awaken the moon from her swooning, or ease her in her labour. The heathen of antiquity lighted up torches, sounded trumpets and horns, and rattled their vessels of brass and iron; and after the eclipse was over, processions and sacrifices expressed their joy at her deliverance. Our compassion withholds the sarcasm, "Lo! these are the gods you worship;" while we cannot but regret the blindness of mankind, who adopted such impotent divinities, who after beholding the utter inactivity of their supposed deities, yet called for help on gods unable to help themselves, and sought protection from gods on whom they also bestowed assistance.

The advantages we enjoy in the science of the present day, enables us to measure and to describe an eclipse with certainty; —the moon now shines full; but first, on her eastern limb we notice a slight deficiency of light; now it augments into a notch of dark; now the dark increases, as she advances into the shadow of the earth, which at length covers great part of her, now it gradually withdraws to the other side of the moon, then becomes scarce apparent even there, till having entirely quitted the shadow, the planet resumes her former lustre.

Such, is the course of eclipses: they are greater or less, as the moon enters more or less deeply into the shadow of the earth and its atmosphere; which, in current language, may pass for one uniform shadow. The longest possible duration of a total lunar eclipse, is three hours, fifty-seven minutes; but a total lunar eclipse may be twenty minutes shorter. The longest total eclipse of the sun (total darkness) is about four minutes; and the time taken by the moon to cross the sun's body (the duration of the eclipse), is, at her nearest access to the earth, about two hours and three quarters.

The moon in the middle of a total eclipse is visible in some places, and invisible in others, according to the different constitutions of the air; but generally she appears of a dusky, reddish, or copper-colour, especially towards the edges: this colour is owing to the solar rays refracted through the earth's atmosphere, and reaching the moon, the red rays being least refracted, they pass through our atmosphere in the greatest quantity.

We

We remarked of the sun, that although he is a globe, yet by reason of his distance he appears *flat*; and the same we observe of the moon; which, though unquestionably a globe, yet presents a *flat* face (termed a Disk) to the spectator. The *SURFACE* of this disk, even to the naked eye, appears rough, uneven, and full of mountains and caverns. A telescope shews very plainly the separation between her enlightened and her dark parts, broken by hills and valleys; in her lately enlightened parts, presenting many dark spots, while in her unenlightened parts, the tops of the mountains and eminences catch the first gleams of the solar rays, and are distinctly seen to enlarge, and become brighter as the light spreads downwards on them. This very agreeable sight requires but an hour or two to complete it.

The mountains in the moon are thought to be higher than any we have on earth, (but Mr. HERSCHELL rather thinks they are not so high) and her caverns proportionally deep; whence some have suggested that if she has any inhabitants, they may use them as cool retreats from the ardour of the sun, which cannot but be very great in the course of a day a fortnight in length. Observe, that during the course of the moon round the earth, the sun enlightens successively every part of that globe, but only *once*; so that she enjoys but one day in all that time: she revolving but once on her axis, consequently but once turning in succession each part of her surface to the sun. Observe too, that as she turns on her axis in the same time as she goes round the earth, the same part of her surface is constantly directed towards us; except what little variation is occasioned by the different courses of the two planets. To explain which, by comparing the face of the moon to a human face, we may say, that we sometimes see less of her right cheek, and more of her left; sometimes more of her right cheek, and less of her left; sometimes we see more of her forehead; and sometimes more of her chin. This is termed her *libration*.

This roughness of the moon's surface is of great use to us: for an opaque body perfectly smooth, is ill-adapted to reflect a considerable quantity of light, but merely glistens in a particular part of its surface, and the rays from the other parts strongly diverge, and are lost, without reaching the spectator: whereas by a rough surface, the rays are refracted innumerable ways, and they fall upon innumerable points, which reflect them copiously in every direction.

In the moon, some parts reflect more light than others; the dark parts have been thought by some to be seas and lakes; and it has been observed, that the line between the dark and light

parts,

parts, is in these places smoother than elsewhere; while others say, they discover even in the darkest parts of the moon, caverns and empty pits; these however *may be* shallows and rocks; or caverns in shallows and rocks.

The enlightened parts of the moon shew darkish spots, which are certainly cavities; for the shadows in them are observed to fall different ways, according to the situation of the sun, and when his beams fall *directly* down them, they have no shadow.

It has been debated whether the moon possesses an ATMOSPHERE: if she does, it is much thinner and more rarefied than our air is, for it has no perceptible effect on the light of the stars, when approached by the body of the moon, but instead of being obscured, or dimmed by it, they preserve their brightness even in actual contact. On the other hand, in certain total eclipses of the sun, a faint pale light has been seen environing the moon, which is best accounted for on the supposition of an atmosphere.

I proceed to suggest a hint or two on the PECULIARITIES *apparent to the inhabitants* (if there are any) of this planet, since in many respects they differ, totally from our observations and inspections of the moon.

(1.) As the moon shews constantly (or nearly) the same side to the earth, those inhabitants *only* who reside on this part of the moon, have a view of the earth; and if those on the other side have curiosity enough to desire the sight, they must take a journey on purpose. (2.) To those who constantly view the earth, it appears fixed, or at least to have no circular motion; or but little according to the moon's libration. (3.) To those who reside in the centre of the moon's visible hemisphere, the earth seems *vertical*, i. e. directly over their heads; as the sun appears at noon to our torrid zone. Whereas, (4.) to those who live in the extremity of that hemisphere, the earth seems stationed in their horizon; and as they move round the earth (monthly), the earth seems to circulate round them, as the sun seems to us to move round the earth. (5.) The earth to the lunarians, has in the course of a month the same variety of phases as the moon has to us; when the moon is at full to us, the earth being between that and the sun, its enlightened parts are turned *from* the moon; it is therefore *new*. As the moon advances between the earth and sun, the enlightened parts of the earth become gradually visible to the moon, and at new moon, it is to them *full earth*; they beholding the whole enlightened terrestrial hemisphere. The light thrown upon the moon by the earth appears a day or two before, and after, the new moon,

rendering the whole of that plane, even its (otherwise) unenlightened and dark parts, visible to the naked eye. (6.) The earth appears to them variegated and spotted, by means of its continents, islands, oceans, &c. By these spots the lunarians will determine the earth's diurnal rotation, as we do that of the sun. (7.) During an eclipse of the sun from us, they will see the shadow of the moon depriving the earth of part of its light, and progressively moving over it in a certain direction; but they will never see the earth totally eclipsed, because the moon's shadow is not broad enough to cover it, but the sun may be totally eclipsed from them for a time, by their immersion in the shadow of the earth.

Having now acquired a pretty good Idea of the nature of the lunar phases, of the moon's share in eclipses, of her external structure, &c. it remains to inquire into some of those benefits which this attendant bestows on us.

As the sun rises he also sets; his absence is the cause of darkness; darkness is unfociable, and gloomy, I might almost say hideous; surely then, we must acknowledge our obligations to the silver moon, whose light supplies the absence of the sun; prolongs the day, sometimes almost doubles it, and though in itself a small body, of only 2184 miles in diameter, yet being near us, the moon affords us more light than all the stars, though probably they are globes of fire; it is true this magnificent reflector is perpetually changing; and her orbit heightens, or lowers, in seeming irregularity; but this irregularity is beneficial; it is limited, so as never to be injurious; and it prevents a constant return of *exact* opposition and conjunction.

The influence of the moon on the tides is well known; by the variations of her orbit they assemble, as it were, in different places, and instead of exerting their force constantly against the same spot, it strikes, now here, now there, so that any one shore is but seldom oppressed by its strongest effort, and consequently is less subject to damage. Nor should we forget that sometimes the moon prolongs the evening of the day, sometimes anticipates the rays of morning: how thankful a benighted traveller for the first! how joyful an almost embayed sailor for the latter! or, when she shines throughout the night, in those parts of the earth where sultry suns scorch the inhabitants by day, they rejoice in the cool moon-light, as in a season of refreshment. The Arab now prolongs his journey, and the camel enjoys the salutary breeze; the very sands, burning but a few hours ago, now become bearable, and seem sensible of their deliverance from the solar fire.

Why

Why is the light of the moon cool? why is it not sultry as that of the sun? (1) Because it has not power sufficient to agitate our atmosphere, nor velocity sufficiently active to rebound in every direction, from every quarter where it strikes, Having previously undergone such refractions and reflections in the lunar orb, like a rebounding ball, it has lost great part of that vigour with which it struck its original object. (2) Because the globular form of the moon *diverges* its rays, every way, whereby a smaller number falls on any given space; and this weakens the lunar rays so greatly, that perhaps at no very extensive distance beyond the earth, she may be scarcely visible. This is certain—that burning-glasses, which, by condensing the sun's rays some thousand times, produce surprising heat, are unable, by any condensation of the lunar rays, to unite them into heat, sensible either to the hand, or to the thermometer.

Should any ask, why shines not the Moon constantly during the night? I reply, night is the season for repose: of what benefit then were perpetual moon light?

But why should the moon perpetually change? Because without such change she could never have fulfilled her appointment, of indicating times and seasons (rural, and civil, perhaps sacred) to mankind, which is evidently her very important charge.

“The first men, affected by the consideration of the twofold service the moon did them, by enlightening the night, and by regulating all mankind, consecrated the use they made of its phases by a holiday or feast, which they solemnized at every time of its renewal. The *Neomenia* served in a plain and commodious manner to regulate the public exercise of their devotion. But if they regularly gathered together to make their sacrifices, and lovingly to visit each other at the return of every new moon, that worship and those holidays were no way relative to the moon itself. God was the object of them; and the moon had no other share therein, but that of putting men in mind of celebrating them.

“The stars had not as yet received the names they now go by. Without taking notice of the several constellations under which the moon is successively placed within the space of its monthly course, men were contented with only determining its progress, by the variety of its appearances; and instead of employing calculations, as has been since done, to mark out the precise instant of its having overtaken the sun anew, under which it had passed nine and twenty days before; the astronomy of those times was contented with the bare testimony of the eyes, and they reckoned the new moon from the day it could be perceived. It was in order

der to get intelligence of it, without hindrance, that they assembled and met together in high places, or in deserts remote from the habitations of men; that no obstacle or any thing might screen the horizon from them. When the crescent had once been seen, they solemnized the Neomenia, or the sacrifice of the new moon, which was succeeded by a repast, where all the families cheerfully, and with simplicity and candour, eat what had been offered to God, and consecrated by prayer. When any notable event occasioned the institution of some annual feast, they very often joined it to the Neomenia, which was the usual day of assembly. The new moons, which concurred with the renewal of seasons, and to which our four Ember-weeks do still correspond, were the most solemn of all. That custom of meeting together in high places or in deserts, that of keeping the new phases, that of celebrating the Neomenia by a sacrifice and by prayers, in particular, the solemnity of the new moon, which concurred with the sowing, or followed the intire gathering of the fruits of the earth; finally, the repast and the songs which came after the sacrifice, are uses, all of which were, from this common source of mankind, handed down to all the nations of the universe. All these customs we find again among the Hebrews, the Egyptians, and the Arabians, from whom they, together with Mahometism, were delivered down to the Persians and the Turks. The same usages were common to the Greeks and the Romans, as also to the Gauls, and to nations which had no manner of communication with each other: They were found again among the Caribbees, and some other American nations.

“Scripture abounds with facts, which evidently prove that the custom of sacrificing on high places was established among the Hebrews as well as other nations, even before the law, and that it even subsisted in Israel since, and in spite of the law.

“If the Hebrews and the Heathens agree together in the practice of their sacrifices, purifications and libations, in their inclination to gather together upon high places, and in the regularity of their Neomeniæ, a grain of sincerity will make us sensible, that the Hebrews are not indebted to the Heathens for these customs, and that the Heathens did not borrow them from the Hebrews; but that both the Hebrews and the Heathens had them from the remotest antiquity, and from the common source whence they all sprung, I mean from the family of Noah, when the whole was contained in the plains of Chaldea. This point of reunion, equally plain and certain, is the sole unravelling of the difficulties which have divided the learned. The whole of man-
kind

kind being gathered round Babel, had already the practice of the sacrifices made before, and renewed by Noah immediately after, the flood. For want of writing, what means could be more natural and more public, to call together to the sacrifice a multitude of families dispersed, than the sight of the decline of the moon, and the return of the new? It is even very likely, that the sun, which before the flood marked the course and the bounds of the year, by the diversity of the stars under which he passed, did it however, without the *Æquator*, and put no difference between one day and another day, or one season and another. The moon was then the most proper means to mark out the beginning and the progress of months: and Noah, when he fixed the religious meetings at the time of the Neomenia, did but renew what was practised before the flood. So the fathers of all nations having been long enough under the same leader, in the same place, united by the same wants, the same language, and the same practices; it is the plainest thing in the world to think that the custom of meeting in high places, and at the return of the new moon the offering of the fruits of the earth, the sacrifices, the common repasts, and the songs, are all usages which have with them passed through the earth. This is what they have constantly preserved ever since their dispersion; and in every other thing, they constantly proceed with making themselves distinguished from each other. You are sensible, how this agreement of all nations in the religious customs, which suited the first ages, and their infinite variations in all the rest, concur to testify the truth of Moses's narration, and the perfect knowledge he had of the origin of things."

"These are the sentiments of a very agreeable author. What a pity is it, that mankind did not preserve pure the memorial of times and seasons! but both unfortunately, and impiously, too strongly venerated the inferior occasion of their assembly, and substituted this *occasion* for the *object* of their worship. I need not here repeat, the costly sacrifices, the pompous offerings, the solemn processions, in honour of Diana, of Lunar or Hecate, *i. e.* of the moon, under a thousand different names, and with a thousand different ceremonies: the queen of heaven had (and has still) numerous superstitious votaries, who, ignorant of philosophical truths, and uninstructed by benevolent revelation practised absurdities, and believed in lies.

There is nothing more important to mankind, than a just estimate of occurrences and circumstances, of things and their properties. Ungrateful! those who continue insensible to the kindness of Providence, in appointing various planets to various duties;

ties; who will not see their order, their beauty, or their importance; but without thankfulness enjoy their benefits, and without gratitude receive their services; who repine at that oeconomy they cannot improve, and deny the excellence of the dispositions of supreme Wisdom. Unhappy! on the other hand, those who overvalue secondary causes, who mistake servants for superiors, who cry to the sun, "O Baal, hear us!" to the moon, "We beseech thine influence!" Unhappy! who rely on created objects for protection, and expect succours even from a radiant planet! It becomes us to remember, that from such superstition we are happily liberated; may we never be enthralled by similar bondage, or be captivated by the subjects of vicissitude, and mutability!

OF THE PLANETS SEEN FROM THE SUN.

HAVING lately described the sun's body as an immense globe of liquid fire, in constant agitation, and, with incessant vehemence impelling from its surface vast floods of light,—to request an excursion to that luminary, may seem to need an apology: what mortal foot shall stand on waves of fire! what earth-born clay support refulgent light!

Descend from heaven, URANIA, heavenly born,
Wisdom thy sister!—Up led by thee
Into the heaven of heavens, we may presume,
Though earthly guests, and draw empyreal air,
Thy tempering:—

Our business here, is, not to examine the refulgent orb itself to admire its brightness, its qualities, or its inhabitants (if it be inhabited); as stranger visitants, we merely request a station on, its surface, from whence to survey the expanse of space around us.

First, we notice that extremely bright little star, which, being nearest, reflects the solar rays with the most sprightly lustre. Mortals on earth have called it MERCURY: that name it may still retain. Somewhat further off, we see (II.) VENUS; next (III.) the EARTH; beyond it (IV.) MARS; then (V.) JUPITER; then (VI.) SATURN;—that, still more remote, has lately been discovered to be a planet by Mr. HERSCHELL, and by him named (VII.) the GEORGIAN planet, in honor of our present

lent Sovereign, in whose reign its nature was first ascertained. Did we possess powers equal to prophetic vision, or "the ken of angels," we might conceive some ideas of the immense intervals between these celestial bodies. If we say, that Mercury is ONLY *thirty-two millions* of miles distant from the sun, that Venus is BUT *fifty-nine millions* of miles, and the Earth *no more* than *eighty-two millions*: we smile at *only* and *but*, as applied to these distances of the inferior planets; what then shall we think of Mars, distant *one hundred twenty-three millions*; or of *four hundred and twenty-four millions*, the distance of Jupiter? Yet this is not the whole extent which requires our survey, for Saturn is distant *seven hundred and seventy-seven millions*; and the Georgium Sidus is very far beyond him.—And this is the *lowest* computation;—recent observations enlarge the distance of the earth, to ninety-six millions of miles, and that of the other planets in proportion.

Nay, we must not startle even at this; for these are only the measured distances of regularly revolving stars, whose courses maintain nearly an equation of distance. There are others, some of whose revolutions are so eccentric, that upwards of *five hundred years* are consumed in one course round the sun: these (comets) are numerous, and they differ from planets, in that they are not stationed at a fixed distance from him, but now approach him closely, now fly off into the immensity of space.

When we consider the vast bulk of the sun, whereby he is fitted to be the centre of the system, and whereby his attractive influence extends immeasurably around him, we must admit the possibility, that other (perhaps many other) planets may be placed at still greater intervals; and this is rendered credible, by the extreme remoteness to which the cometary orbits extend; for if at that distance, the sun's power re-attracts those bodies, why may it not also determine the courses of others in regular orbits?

Supposing ourselves in the sun, we should see the planets lately mentioned, describing a path in the heavens, as *among the stars*: under which idea we offer a few remarks: (1.) To a spectator in the sun observing a complete revolution of the planets, they would appear to move steadily and equably round him from right hand to left; without hurry as without delay. (2.) Although they would appear to move nearly in the same plane, yet it would not be *exactly* so; but it would very rarely happen, that one should hide another from his sight; they would be either a little higher, or a little lower, one than another, so that in general they would all be visible. (3.) If we suppose them
to

to be all in one direct line from him (I say if looking forward, he saw them all in one line) when beginning his observation, yet, by reason of the smaller orbits of some, and their consequent differences of apparent velocity, such a regular line would quickly appear disordered; one might perhaps have got a quarter of his orbit, another an eighth, another a tenth part, and so on:—further still, when one had appeared to have proceeded half his revolution, and the spectator, wishing to observe him, must turn his back to his original station, yet in that station he would leave some who would appear scarcely to have moved by the time others had completed their courses. (4.) As these planets shine by light received from the sun, each would *always* shew its illuminated half to the sun.

All the planets appear white or luminous; because their surfaces reflect the light received from the sun, except that refraction of it on their rough surfaces, which we mentioned with regard to the moon, whereby we are enabled to see them. There is however some little difference in the colours of the planets, as their surfaces are differently modified. Venus inclines a little toward yellow; Mars is somewhat reddish; Jupiter very white; and Saturn a little livid; one reason of which may be his great distance.

The periodical times of the planets may be expressed in round numbers, by saying, that Mercury circulates round the sun in three months; Venus in seven months; the earth in twelve months; Mars in two years; Jupiter in twelve years; Saturn in thirty years; and the Georgian Sidus is thought to take seventy or eighty years, to complete a revolution.

¶ We remark here that there is a regular ratio between the times of the planets revolutions, and their distances from the sun; Mercury, distant thirty-two millions of miles takes but three months; while Venus, whose distance is 59 millions of miles, (and who consequently has a more extensive orbit to pass over), is allowed a proportionally greater time, *viz.* seven months; the earth requires twelve months, to perform a course whose distance is 82 millions of miles. Double the time is allowed to Mars, because his orbit is nearly double this distance, being 123 millions of miles; and Jupiter and Saturn are indulged with many years, because the distance of the first is 424 millions of miles; and that of the latter is 777 millions of miles; to which thirty years are not more than adequate. The distance of the new planet, is more than 1700, millions of miles, to 83 years.

The enumeration of so many millions of miles, is inconvenient, and apt to burden the memory; for abbreviation, we divide

vide the distance of the earth from the sun, into *ten* parts. at four such parts from the sun, we may estimate Mercury; Venus at seven such parts; the Earth, at ten such parts; Mars at fifteen, *i. e. half as far again* as the earth; Jupiter at fifty-two such parts, *i. e. more than five times* as far from the sun as ourselves; and Saturn at ninety-five such parts, between nine and ten times our distance.

Though we have thus stated the distances of the planets from the sun, and though we have said to a spectator in the sun they would appear equable and constant, yet, in reality, part of each of their orbits, is a little *further* from the sun than the mean distance; and the opposite part of the orbit, is a little *nearer* to him than the mean distance. If I knew any one English word which would express *nearer-to-the-sun*, or, *further-from-the-sun*. I would readily adopt it, but as our language affords no adequate expression, astronomers call *Perihelion*;—the nearest distance of a planet to the sun, and *Aphelion*—the greatest distance of a planet from the sun; these terms are derived from the greek language. These points, we must remember, are always *opposite* to each other in the orbit of a planet. The perihelions of the planets are in different points of the heavens.

Those bodies nearest the sun must needs receive most of the sun's light, and that light must produce proportionally greater effects upon them; provision is made for their sustaining these effects, by a variation in the densities of the planets. Mercury, which is nearest to the sun, is most compact, and dense; Saturn, is of looser texture; the Earth which is between these planets, is between them in density. The difference is not very considerable; but as it seems to be appointed by Infinite Wisdom, it is not, cannot be, unworthy our notice. The whole bulk of the planets united, is but one six hundred and fiftieth part of the bulk of the sun. We shall now notice these bodies in order.

MERCURY is the nearest planet to the sun; the eccentricity of his orbit is considerable, being above one-fifth part his mean distance, or the semi-diameter of his orbit. In bulk, he is the smallest of the planets, being in diameter only 2,160—some say—2,600 miles. His light is extremely bright and lively, owing probably to his nearness to the sun. He circulates round the sun in 87 days, 23 hours, 16 minutes, travelling 95,000 miles *per* hour. He has no moon; nor from his situation has he need of any.

VENUS, the next planet to Mercury, moves in nearly a circle round the sun 69,000 miles *per* hour; her axis is somewhat inclined to the plane of her orbit. Her bulk is nearly that

of the earth, being 7,900 miles in diameter; her light is splendid; no moon has yet been discovered to accompany her; she circulates round the sun in 224 days, 16 hours, 49 minutes; at the rate of 69,000 miles *per* hour. Spots have been seen on her surface; which indicate a daily rotation on her axis in 23 hours; but some gentlemen have given for her rotation 24 days, 8 hours. Instead of revolving from west to east, as the earth does, *i. e.* nearly with a *horizontal* motion, she revolves almost north and south, *i. e.* with a motion within 7 degrees of *perpendicular*.

THE EARTH moves in nearly a circle round the sun (her eccentricity being only 17 parts in 1,000); her axis is inclined to the plane of her orbit, no less than 23 degrees, 30 minutes: she is 7,950 miles in diameter. The Earth has one moon (which circulates round her in 29 days, 12 hours, 44 minutes, turning in the same time on her own axis, and shewing spots: She is 2,180 miles in diameter). The earth has a daily rotation on her axis in twenty-four hours, travels 68,000 miles *per* hour.

MARS has an eccentricity of nearly one-tenth part of the semi-diameter of his orbit; his axis is not perceptibly inclined to the plane of his orbit: his diameter is 4,500 miles; he has no moon, but a very large and dense atmosphere, which probably performs some of the offices of such an attendant. His daily rotation on his axis is performed in 24 hours, 40 minutes, as is calculated by his spots: he circulates in 686 days, 23 hours: travelling 47,000 miles *per* hour.

JUPITER's eccentricity is about one-twentieth part the semi-diameter of his orbit (48 parts of 1000); his axis is nearly in the plane of his orbit; his diameter is 81,000 miles, being by much the largest of the planets, and ten times the diameter of our earth. He circulates in 11 years, 314 days 12 hours, moving 25,000 miles *per* hour. He has four moons;

The *first*, distant from his body five semi-diameters and three-quarters; revolves in one day and three-quarters.

The *second*, nine semi-diameters; revolves in three days and rather more than half.

The *third*, upwards of fourteen semi-diameters and a quarter; revolves in seven days, three hours, and three quarters.

The *fourth*, twenty-five semi-diameters and a quarter; revolves in sixteen days and nearly three quarters.

His spots are so considerable, and occupy so great a part of his surface, and lie in such directions, that they are denominated his *Belts*: what they are, is not determined; their appearance often varies. His daily rotation is performed in 9 hours 56 minutes. The figure of Jupiter is not that of an exact globe; his

his diameter, at his equator, being longer than his diameter between his poles, as 13 to 12, the difference is 6,230 miles.

SATURN's eccentricity is rather more than one-twentieth part the semi-diameter of his orbit (55 parts in 1000); his diameter is 67,000 miles; which is 14,000 less than Jupiter, he circulates in 29 years, 167 days, 5 hours, moving 18,000 miles *per* hour. He has five moons.

The *first*, distant from his body, nearly five semi-diameters of the planet; revolves in less than two days.

The *second*, distant six semi-diameters and a quarter; revolves in 2 days, 17 hours, $\frac{3}{4}$.

The *third*, distant eight semi-diameters and three quarters; revolves in four days and a half.

The *fourth* distant twenty semi-diameters and a quarter; revolves in 15 days, 22 hours, 41 min. 13 sec. 4.

The *fifth*, distant fifty-nine semi-diameters and upwards; revolves in 79 days, 7 hours $\frac{3}{4}$.

Dr. HERSCHELL has discovered two more satellites to Saturn; revolving in the plane of the *Ring*, within the former first satellite; their periods are, of the 6th Satellite 1 day, 8 hours, 53 min. of the 7th Satellite, 22 hours, 37 min. 22 sec. Distance of 4th from Saturn's center 3 min. 8 sec. 918. Distance 6th Sat. 36 min. 7889. Distance 7th Sat. 28 min. 6689.

Beside these seven moons, he has a very wonderful *Ring*, which encompasses his body at 20,000 miles distance from it, and is resplendent. His daily rotation is not determinable, his distance rendering his spots very obscure. His ring is thought to have a rotation, and to be 20,000 miles across. In proportion to the planet, it is about twice and one-third his diameter; his ring revolves in about 10 hours, 32 min.

Of the GEORGIUM SIDUS, the mean distance is nearly twenty times the distance of the earth: the inclination of his orbit 46. 26. The period in which he circulates round the sun is 83 years 16 days, his diameter is four times and one third that of the earth: his bulk eighty times and a half that of the earth: two satellites have been discovered belonging to him; of the first the period is 8 days, 17 hours, 1 min. 19 sec. Distance 33 min. of the second the period is 13 days 11 hours, 5 min. 1 sec. Distance 44 min. 23. His orbit is inclined to the ecliptic—90°.

Thus have we noticed the planets as they are related to the sun, and seen from him; they have other peculiarities as seen from the earth; but those we propose to explain hereafter.

With what difficulty do we form any idea of distances so extensive as those of the planets! we conceive readily of a yard, or

of a mile, because the measure is familiar to us. To those who have journeyed an hundred miles (or to any who have visited India) the distance is within comprehension; but when we speak of a million of miles, of fifty, or an hundred millions of miles, who comprehends the computation? We rather incline to accept it as an instance of the power of numbers, than as actual measurement of space; and because unaccustomed to a scale of such magnitude, we are perplexed at the extension we can neither comprehend nor deny. We pretty much resemble an honest native of St. KILDA (an island in the Atlantic Ocean, a little distant from Scotland, whose inhabitants are a few families in native simplicity); this uninformed rustic had never quitted his rock, or seen other shores; he had heard of Scotland, and only heard of it: when conveyed to the nearest coast, what an immense voyage had he not accomplished! his ideas never conceived of so great a space! When, on a gentle acclivity, he surveyed the adjacent country, it exceeded now his belief, though he saw it with his eyes, as before it had exceeded his comprehension: with what sensations would this simple swain have beheld a globe, could we suppose him to understand it, or what effect would the relation of a voyage to China have had on his mind! But surely the dimensions of the globe were not lessened, because his ideas were contracted; and what should we think of his incredulity that such or such places existed? It was remarked of him, that he could not understand the mechanism of a coach-wheel; yet we know that coach-wheels revolve; and so will the planets continue their courses, whatever sentiments they excite in our minds.

What power impels them round the sun? They follow now the impulse and the laws of that motion first impressed on them, when their Almighty Maker spake, and it was completed, commanded, and it was done. Their courses were appointed by Infinite Wisdom, directed by unerring skill, accomplished by supreme energy. That Power only which could create them was competent to conduct them, and by that Power they revolve. But though we refer to Divine Omnipotence the ability to communicate, and to continue, the motions of these immense globes, yet, by comparison of great things with small, we acquire some insight into the laws and regulations, whereby they are now governed. The most familiar instance I recollect, as explaining the nature of planetary motion, is this: we have often whirled around our finger a small weight at the end of a string; had we suddenly quitted the string, the weight would have quitted its *circular* motion, and would have fled from us in a *straight* direction

tion, prompted by its natural inclination ; which inclination contributed to its motion while held, and that motion, by our hold of the string was rendered circular ; (*i. e.* around the hand). In this instance the hand represents the sun, and the string represents the solar attraction. Were the planets desirous of escaping from their places, they are withheld by this attraction, whose constant power, acting in every point of their course, affords no moment of opportunity wherein to elude its vigilance. This attractive force neither diminishes nor increases, but continues as at first appointed, accurately counterbalanced by the interval of proportionate distance, and the impulse of regulated velocity, whose rapidity augments, when attraction is most powerful.

That power which appointed the orbits, directed the courses of the planets, and confined them nearly parallel : it might have been otherwise ; some might have moved horizontally, others perpendicularly (comets thus vary) ; but Wisdom has decreed, and the planets obey. Those among mankind who scorn confinement and restriction, who think ever to be uncontrolled, and to follow without obstacle the wild impulses of their own hearts, would they but reflect on the confusion such principles (rather want of principles) would occasion in the very system of the world, they might surely discover that restraint accompanies every existing creature, and that order is as necessary as being. From this universal law how should man be free, whose importance justifies attention, whose propensities require regulation ? Let us ever desire to fulfil aright our destined courses, and if, in the courses of our friends, we observe any eccentricities, let us hope a little time will restore them to their just situations.

Having noticed the planets, I shall offer a remark on the nature of COMETS, of which we have many belonging to our system, (perhaps a hundred), and observation is frequently discovering additions to the catalogue. These revolving bodies were once thought to prognosticate direful events, bloodshed, war, devastation, and (worse than eclipses !) were regarded as ominous forerunners of final dissolution. Better informed science considers these tremendous strangers as revolving round the sun, in orbits no less regular and periodical than those of the planets ; principally differing, in that the planetary distances are constant, and their courses circular, while cometary orbits are so exceedingly elliptical, that some of them advance to the sun in a line nearly strait, and return in a line not sensibly different. Moreover, the extremes of this line are extremes indeed ; when near-
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est the fountain of light, almost striking that resplendent orb; when furthest from it, distant immensely beyond the station of any known planet. There are great differences in the orbits of comets; some stretching prodigiously into space, and exceeding five hundred years in one revolution; others advancing toward the sun a little beyond the orbit of Mercury, and completing a period in seventy-five years; some revolving in one plane, others in a contrary; some flying on the right-hand, others on the left; some above, some below. Notwithstanding the number certainly known, very probably many have never been noticed, their position in their progress having concealed their distinguishing character, *the train of tail*, which, while they advance, kindles and increases by degrees; while they return, by degrees decays and ceases. Add to this, that such as have passed us in those parts of the heavens which were above our horizon in the day-time, were rendered invisible, like the stars, by the superior brightness of the sun. Also, being of different magnitudes, perhaps we scarce discern the smaller; or, if we discern, we do not distinguish them.

What shall we suggest as the use of Comets? Do they visit the sun, and import fire and heat to remoter parts of the system? Are they connecting links between system and system? Have other systems their comets occasionally visible by their near approach (perhaps mistaken sometimes for new stars), as ours perhaps approach others? This seems likely:—that by their access to the sun they are violently heated, by their ultimate distance they suffer extreme cold.

Sir ISAAC NEWTON thought comets might supply moisture to the planets, from time to time, by the vapour of their tails; and from time to time, by falling into the sun, might contribute fresh matter to repair the waste of that fountain of light.—O for the ultimatum of human enquiry; for the bounds of human curiosity!

Are the planets inhabited? I scruple not to affirm it. Are the comets? We cannot tell; but as they seem subject to extremes, now glowing with solar fire, now frozen with the energy of cold, perhaps they are not fitted for dwellings: accept it so; and then reflect, if you please, that we have comets on earth; we see them from time to time among mankind; how they now blaze! what brilliancy, what splendour! what commotions do they not excite! what remarks do they not occasion!—Wait a little:—their splendour weakens, their pomp declines, their distinction ceases, they are visible no more: inferior in this respect to celestial comets, which shall again return, these, when extinguished, become “stars of perpetual darkness!”—

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While the more ordinary and regular, the constant, and stationary planet, affords habitation and support to millions of creatures; while it receives the blessings of millions of inhabitants, by whom it is cultivated and adorned; while it enjoys the grateful vicissitude of day and night, an equal temperament, and a lasting share of celestial influences, it may well view without envy the cometary perihelion, and rather pity than regret cometary distinction:—is this in no respect analogous to incidents of human life? If it is, the planetary orbit be the station for me!

OF THE PLANETS AS SEEN FROM THE EARTH.

THE magnificent objects we considered in our last discourse, are so remote from the earth we inhabit, that it seems natural to inquire of “what advantage are they to us? and how do they appear, when seen from our residence?” But previous to answering these questions, our attention must be directed to a few observations.

Was I to ask any foreigner where he lived? and he should vaguely answer, in Europe; I should find it necessary to inquire further, in what part of it? But if he replies, in such a city; I am enabled to find it, on a globe, or a map, by inquiring its latitude and longitude; *i. e.* by ascertaining its relative situation to certain points from whence I begin my calculation. Europe is large, but by being divided into smaller spaces, we readily find any one space, and by its smallness are enabled to inspect it accurately. Just so are the heavens; too extensive to suggest any determinate idea from a vague expression, and, therefore, it has been found necessary to regulate, and divide their extent. The wandering planets afforded no rule for this, and the sun, though fixed and at rest, contributed little towards it, because he *seemed* in motion. Recourse was had to those infinitely more distant stars whose permanent stations afforded *fixed* points for determination; and these accomplished the purpose, because, the eye, unable to judge accurately of their distances, considered all the celestial bodies as equally remote.

The first application of such principles, seems naturally to be to ascertain the *apparent* path of the sun in the heavens; according therefore as that luminary *seemed* to proceed gradually from place to place, and these places were referred to such and such stars, those

those stars became of more consequence, and were more accurately attended to, than others.

Whether the earth goes round the sun, or the sun goes round the earth (as he seems to do) the spectator will behold the sun proceeding in the same orbit in the heavens. Now in order to determine at any certain time, at which point in his annual orbit was the sun's station, it became necessary to divide this orbit into parts; accordingly, it has been divided into *twelve* parts (a corresponding number to the months of the year); and the stars which lay near to the solar path, by the fertile imaginations of the beholders being likened to certain forms, were taken to represent such forms, in twelve divisions, and relative names were appointed to each.

The path of the sun was called the **ECLIP TIC**; and is not always of apparent equal height in the heavens, because, as we have observed, the axis of the earth being inclined to the plane of its orbit (*i. e.* to the apparent path of the sun round the earth, or the real path of the earth round the sun), the sun seems at one time to be heightened above his just station, at another time to be depressed below it.

Mankind were originally husbandmen, or shepherds, and ideas drawn from these occupations were ever uppermost in their minds, and willing to renew and maintain them, they transplanted their cattle even into the heavens. Or, having observed that at the time of the sun's being in such a division of the ecliptic, their cattle were most prolific, they gave the names of such as then produced young, to that constellation in which the sun then was. But some persons have suggested, that the signs and constellations of heaven are commemorative of historical important events: a principle not to be disregarded.

We must now, imagine ourselves transported to a climate, where the natural events of husbandry would agree with the order of the signs in the Ecliptic, as in this climate they will not justify the significations attributed to them.

The constellations reckoned to the **SPRING** season, are, the Ram, the Bull, the Twins (properly the two kids). The ram alludes to the time of increase among the flock, and the bull to the fertility of the herd; if we further suppose that the twins related to the goats, and not (as now delineated) to the human kind, we have the three chief objects of the shepherd's care, in the signs of the spring-season in the months of March, April, and May. The **SUMMER** constellations—the Crab, the Lion, the Virgin (June, July, August), have been thus accounted for: the Crab, being an animal which walks backward, is thought to have

have signified the retrograde course of the sun, which from Midsummer is regularly declining from the highest reach of its path in the ecliptic. The sign of the lion seems to imply, either, that now this savage animal was unusually ferocious (being heated by the ardent beams of the sun, and its natural fever increased), or, that the heats of the season, too nearly resembling the lion by their fierceness, were no less destructive. The virgin, is certainly a reaper, holding three ears of corn. The AUTUMNAL signs are, the Balance, expressing the equality of days and nights in September. The Scorpion, having a venomous mischievous sting, has been thought to signify, that where these signs were first adopted, the sun left behind him diseases and mortality in October: the Archer, or Huntsman, aptly expresses the exercise of the chase, in November, after vintage and harvest are over. The wild Goat, the first of the WINTER signs (December), has been supposed to hint the re-ascent of the sun in the ecliptic, because that animal is perpetually climbing and ascending the steepest rocks. Impetuous Floods mark January; and the pair of Fish, seems well adapted to the season when those creatures were objects of pursuit, in February.

The extent of these signs in the heavens, is ten degrees above and below the ecliptic: so that they include a belt of twenty degrees broad, which, from these ideal figures of animals, is called (the Animal-belt) in Greek the ZODIAC. The signs of the Zodiac are very ancient, so ancient that I suspect them to be changed from their original ideas during a lapse of time; however we accept them now, as they are. The country where they were first adopted is uncertain, some authors contending for Egypt, others more plausibly, for India.

Thus, did human industry and contrivance, distinguish the (apparent) path of the sun, from the general expanse of the heavens: the paths of the planets accompanying this course, the fixing of one readily determined the others.

We shall now, bestow a few thoughts on each of the planets, as seen from the earth. We have formerly noticed the immense magnitude of the SUN; but, when surveyed from the distance to which the earth is appointed, he seems too small to excite the idea of so vast a bulk: the mean apparent diameter of the sun being thirty-two minutes. I say his *mean* diameter, because the earth in common with the other planets, having her *perihelion*, and her *aphelion*, her nearness to the sun in the former, increases his apparent magnitude to thirty-two minutes, thirty-seven seconds, as her greater distance in the latter, diminishes it to thirty-one minutes, thirty-two seconds.

Contrary to what might be supposed, by cursory imagination in our part of the world, the perihelion of the earth is in December, so that we are really nearest to the sun in winter. Our seasons therefore do not depend on this circumstance, but are more nearly related to what we shall next observe, *viz.* that the course of the sun in the heavens, is sometimes long continued, and very highly elevated above the horizon, sometimes but little distant from it. In mentioning the earth, among the planets we said, her axis was inclined to the plane of her orbit twenty-three degrees and a half: it follows, that in the course of her annual revolution twenty-three degrees and a half of her surface toward each pole of her axis, is turned more directly to the sun at one time than at another: and by so much as she turns more of any part of her surface to the sun, by so much longer is that part exposed to the solar beams during her daily rotation. So that instead of having at London twelve hours day, and twelve hours night (as, if the earth was perpendicular to the plane of her orbit, we should always have), we have sometimes barely six, sometimes more than sixteen: as at the pole, they have sometimes no day during two months (in winter), no night during two months (in summer).

We shall now remark a particular appearance of the moon, as seen from the earth: which is, that about the end of July, to the beginning of September, the moon, when just past the full, rises several nights together soon after the sun sets; so that twilight is scarce begun, ere the moon appears, and prolongs the light, to the great benefit of those who have harvest-work to do, and she is therefore called the *HARVEST-MOON*. This depends on the course of the moon, which is sometimes more directly *downwards*, sometimes more *obliquely*: the oblique course carries her but little below the horizon daily, so that the following day in the evening she rises so much nearer to her station on the evening before. This is one effect of that beneficial irregularity which we formerly noticed.

Beside these appearances, we observe in both the heavenly luminaries, when near the horizon, a variation in form from their true shape, and also enlarged dimensions: this is most remarkable with regard to the moon.—

It can scarcely have escaped notice, that the moon seems much larger when seen in this situation, than when high in the heavens; the cause has been much debated. Certainly, the cause is near ourselves; but whether arising from the vapours of our horizon, or from a comparison with other objects to which she is near, or from the effect of her light (which is but weak) on the

the eye, philosophers are not satisfied. For my own part I think the terrestrial vapours contribute the greatest share to this peculiarity; and it should seem to be most sensible, when the atmosphere is most loaded with transparent vapours: but this is agreed, that, when measured by the telescope, no variation of diameter can be discovered.

The mean apparent diameter of the moon is thirty-one minutes, sixteen seconds; her smallest diameter is thirty-one minutes, three seconds; her largest, thirty-one minutes, thirty-eight seconds.

We will next consider the aspects of the planets. We are not now surveying the planets from the sun, but from the earth and therefore, may adopt whatever notions of the inhabitants of earth are not contradictory to nature and to fact. We denominate those planets nearer to the sun than ourselves, *inferior*, and those further from the sun than ourselves, *superior*. The inferior planets consequently, are Mercury, and Venus. These have so many appearances in common, that when we have attained a distinct idea of either, we have little to add concerning the other.

(1.) The course of their motions being *within* the course of our motion with regard to the sun, it will naturally happen that they sometimes are exactly between the sun and the earth, so that looking to the sun we should (supposing their light strong enough) see the planets also; and this must needs be their nearest approach to the earth, or *Peri-Geo*, and not only may the planets be thus in *conjunction* with the sun, but if the conjunction be absolutely *perfect*, a line drawn from the sun to the earth, will pass through the body of the planet; hereby the planet intercepts so many of the solar rays, as are proportionate to its magnitude, and *eclipses*, to a certain degree, the sun from us. This passage of a planet over the face of the sun, is called a *Transit*, and can only happen to inferior planets. Thus, Venus may see a transit of Mercury; the earth of Venus and Mercury; Mars of the earth also, and so on. But Mercury never sees a transit of Venus, because the path of that planet never lies *within* his orbit. Transits are very rare.

(2.) We have supposed the planet to be between the earth and the sun (this is called an *inferior conjunction*); but this same planet, in pursuing its course, must sometimes be beyond the sun—from us; (this is a *superior conjunction*), inasmuch that the sun may pass over the face of the planet, as before the planet passed over the face of the sun. When a planet is thus situated, the effulgence of the sun's rays prevents its being visi-

ble. There are therefore two periods at which the inferior planets are invisible, *i. e.* the *conjunctions*, when the sun's rays are coincident with the planet, and too powerful for it. Add to this, that in the *inferior* conjunction, the dark part of the planet is turned toward us. These planets, then, pretty nearly resemble our Moon in her course, being new (or dark), horned, half-light, full, and so on, in each revolution.

If the earth was not a planet, but fixed, these conjunctions would happen in every revolution of these planets round the sun; but as the earth circulates round the sun as well as these planets, conjunctions can only happen when two planets are in the same part of the heavens, seen from the sun.

But though the earth be a revolving planet, we shall suppose her to be at rest, while we attend to one revolution of the planet Venus. Now that planet in her course first passes on pretty briskly, according to the order of the signs; but shortly, her pace slackens, she stands still, then she returns back in her course, till again she seems motionless, from which recovering, she resumes her original progress, and again advances in the order of the signs. This is the necessary effect of her circular course.

To render these appearances clear, take a small wheel, which lay flat on a table; then erecting a wire on any part of the circle (or periphery) of the wheel, put on the top of the wire a small object for convenience of seeing it; now place a candle on one side of the wheel:——and trace, the shadow of the ball on the wainscot, turning the wheel round. The shadow moves first to the left, then it returns to the right, at each revolution of the wheel; and at each extreme it seems to move with diminished velocity.

The inferior planets can never be very much elongated from the sun, but their greatest distance from him will always be proportionate to the confined dimensions of their orbits: thus Mercury, whose orbit is small, is so constantly a neighbour to the sun, that he was long unnoticed by the early astronomers. He is only discernable for a little while after sun-set, and a little while before sun-rise, and always in that quarter of the heavens where the sun is, inasmuch, that during a great part of his course, he is obscured by the solar beams. On the same principle Venus, though seen later in the evening than Mercury (her orbit being larger), yet always sets before midnight.

If such peculiarities in the courses of these planets do not prove that they revolve round the sun, yet I think we may defy the acutest maintainer of that system which supposes them to revolve round

round the earth, to account for them fairly; nor is it possible on that scheme, to account for the different apparent magnitudes of these planets, in *perigeo* and *apogeo*. Venus when nearest to the earth measures seventeen parts in diameter, of which when furthest from the earth she is only three. Mercury is in perigeo to his diameter in apogee, as fourteen to six.

Those planets, whose orbits are *without* ours, are termed Superior Planets: In common with the foregoing, these have the appearances of being progressive, then stationary, then retrograde and stationary again. They are also in some parts of their orbits nearer to the earth, in others more remote. They can never transit the sun's face. A conjunction of a planet is, when the sun, that planet and the earth are in one line: but, as in this case, to trace the progress of such a line, we must, to view the planet, turn our backs on the sun, this situation of these bodies is termed *Opposition*; the proper conjunction of a superior planet, being only when it is behind the sun,—from us.

We supposed, that while an inferior planet went round the sun the earth continued still; let us now change the supposition, and imagine that while the earth revolves round the sun, a superior planet (Mars, as being nearest) remains fixed. The effect would be, that when the earth is farthest distant from the planet, the planet would seem direct in motion (*i. e.* according to the order of the signs); as the earth advanced in the *turn* of her course, as we may be allowed to call it, the planet would seem stationary, and when the earth was in her nearest semi-circle, the planet would seem retrograde. But we must remember, that as neither of these bodies do in fact stand still, their appearances are proportionately varied in nature.

The smaller the orbit of a planet, the sooner it accomplishes a revolution: Venus, who finishes her course in seven months, while the earth takes twelve, will be advanced five months in another course, by the time the earth has concluded her old one, as the earth will complete a whole revolution, and almost a second, while Mars is fulfilling his orbit. The difference of the apparent velocities of two planets, is usually calculated, by supposing a spectator in the sun, to observe their revolutions, and to estimate the daily difference of their motions. The daily mean motion of the earth, would appear to such a spectator to be fifty-nine minutes, eight seconds; the daily mean motion of Venus, one degree, thirty-six minutes, eight seconds; the difference thirty-seven minutes: now, therefore, as thirty-seven minutes is to the whole circle of three hundred and sixty degrees, so is one day to the whole course of Venus, till she returns into the same relative

relative situation to the earth (conjunction if you will), which requires above five-hundred eighty-three days. The daily mean motion of Mars is thirty-one minutes, twenty-seven seconds; and the earth takes to recover any given situation with respect to Mars, two years and fifty days. The mean motion of Jupiter is four minutes, fifty-nine seconds daily: the interval (of a conjunction, &c.) is one year, thirty-three days. The mean motion of Saturn, is two minutes daily: the interval, one year, thirteen days. The motion of the Georgian planet is so slow: that his places are calculated only for one day in a fortnight, during which he scarcely seems to change place at all. We observe of the inferior planets, that they shew to the earth the same changes in their light as our moon does; the superior planets never shew such changes, but constantly shine full, except Mars, who is much darkened when in quadrature.

MERCURY is so small, so distant, and so near the sun, that little can be added to what has been already hinted.

VENUS we can see longer than we can see MERCURY. She is sometimes visible only in an evening, and is then called the Evening Star, or HESPERUS; sometimes only in a morning, and is then called the Morning Star, LUCIFER, or PHOSPHORUS: *i. e.* before her *inferior* conjunction with the sun, she sets *after* him; *after* her conjunction, she rises *before* him, and increases the time of her appearance above the horizon, according to her distance from the sun. The splendour of this planet is so lively, that at certain periods of her revolution she is visible even in the day-time: and her light is often brighter than an equal space of light on the surface of the moon.

Of MARS I shall not add to what I have already observed.

JUPITER is of so great magnitude and brightness, and on account of his system so important, that he must not be passed over in silence. It is a very pleasing sight through a telescope, to observe this planet with all his moons about him like a parent whose children are constantly employed in his service. These moons, like our own, are *eclipsed* by passing through the shadow of their primary; as at other times, the primary receives a shadow from them. These eclipses have been proposed as the readiest way of determining the longitude, and to them we are indebted for the first proof of the travelling of light.

The system of SATURN, is a wonderful contrivance: what we know of him (and his distance precludes the expectation of a perfect knowledge) excites our admiration. As seen from the earth his moons are extremely small, and only to be discerned by the

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best glasses, and in a favourable state of the air. The appearance of his ring is constantly varying, as it is more or less oblique to our view, and to the solar rays; which sometimes illuminate the upper, sometimes the under surface of it, but which, when they strike against its edge, are not reflected with sufficient strength to transmit light throughout an interval so prodigious.

After surveying such an august combination of wonderful structures: after having traced the principles of their revolutions, and somewhat inspected their appearances; it would be almost criminal in us to deny our improvement, as well in morals, as in knowledge; for surely, the variety, the order, the beauty, the constancy, the utility of these planetary globes, cannot be regarded without considerable emotion of mind.

We are taught by the highest authority, to regard all mankind as brethren; all mankind on the face of the earth: I may justly extend the precept, and regard as brethren all who tread the surface of our neighbour worlds. Need I scruple to consider these worlds as so many residences of intelligent beings? I think not: how nearly they may be allied to ourselves in nature, we must ever continue ignorant: yet, in some respects, the similitude is undeniable. (1.) By the revolutions of each globe on its axis, they, like ourselves, possess the vicissitude of day and night; for what imaginable reason, but to distinguish the periods of labour and repose? Like ourselves they need refreshment; and to them, as to us, the lustre of day, and the tranquillity of night is grateful. (2.) Providence has kindly furnished them with numerous substitutes for the sun, that their night may never know the melancholy of total darkness, and may often be enlightened by several attendant satellites at once: does this imply, that some cease not their studious contemplations, but as well by night as by day, prolong their researches into knowledge and science? Or, is this favouring distinction diverted by avarice to serve its sordid purposes? to whose ardent pursuit of wealth the day is too short, and whose grasp includes the additional hours of night. It is probable, I say, they have among them busy spirits to whom the day is insufficient, who add store to store, whether of wealth or knowledge, whether of fame or of power. When acquired, do they retain it?—Perhaps, like us—they die. This I think certain: attendant satellites are useless to a barren planet. (3.) They also have a variety of seasons; in Venus very considerable; in Jupiter, scarce sensible as to length of day and night, but probably very different as to rain, &c. (4.) They have also sea and land; for thus we account for their spots; the bright spots are mountains,
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the dark spots waters ; and much as our Atlantic Ocean, with a large island in it, might appear to them, are some of their appearances to us.

Shall we trace a kind of connection (an imaginary kind of connection I allow) which circulates around us : two persons who dwell in the same street, though perhaps they are not intimate, yet if they meet at the further end of the town, they acknowledge each other as neighbours : two townsmen, at an extremity of a kingdom, consider each other as fellow-citizens. In some foreign European state, two Englishmen are social, as compatriots ; to Europeans in China, distinction of nation ceases. So might we imagine inhabitants of this globe (choose what extremes you will), removed to Jupiter or to Saturn, they would probably lose the idea of their original distance, and claim kindred as fellow-globesmen. Fancy may carry the idea yet further, and suppose in some remote fixed star, a meeting of natives of the earth, of Jupiter, of Saturn, would they not associate by planetary connection, and urge as a reason,—why, he belongs to our system ? How extensive in the human heart is the principle of self ! our system !

The various provisions made by our common Author for the well-being of his various works, should excite not only our esteem, but also our dependance and trust. Infinite Wisdom neither with-holds, nor wastes its efforts. To a planet so near the sun as Mercury, its portion of solar light is abundantly adequate to every want of its inhabitants, inasmuch, that probably that abundance is moderated. Mercury therefore requires no moon, it would be superfluous ; but let the inhabitants of earth accept with thankfulness the services of that lucid orb which waits on them, which dissipates the obscurity of night, and “ shadowy sets off the face of things.” Planets more distant from the solar fire, enjoy yet greater attention ; four moons, instead of one : or if four be insufficient, behold seven, together with a vast ring of light ; an atmosphere of lustre !

When I have heard the dispensations of Providence arraigned, how have I wished that such persons had reflected on the constitution of things ! What ! vain man, wouldst thou displace the appointments of Omniscience ; or, art thou discontented with his disposal of *thee* ? Then let thy sagacity control the ordinances of Heaven, deprive Jupiter of his satellites, and bestow them on Venus ; divest Saturn of his appendage, and ornament Mercury with his belt. Do you fret and fume that other planets abound in lunar attendants, while we have but one ! We have but one moon, it is true, but by how much are we nearer the sun ?

fun? The usual cause of discontent, is inattention to both sides of our condition; did we see rightly our own advantages, and were we acquainted with the draw-backs on our neighbour's apparent happiness, envy and discontent would nearly vanish from among us.

It is curious to trace the progress of idolatry; of which Zoroastrianism, or the worship of the Host of Heaven, is certainly most ancient. We have already noticed its prevalence with regard to the sun, whose invigorating influences seem to have given some kind of support to the practice, especially if, as we may suppose, it was introduced at first, in the form of simple salutation.

The moon seems next to have engaged the superstition of mankind, very naturally.

Without offering the least vindication of the absurd impieties of former ages, let us reflect on the probable course of their error, with regard to the planets. Idolatry seems to have originated in the East, where also Astronomy originated; the vicissitudes in the aspect of heaven was there quickly noticed, through an air serene, clear and transparent. Add to this, that the ardent heats of day were almost insupportable, and evening and night were times of enjoyment. To those therefore who anticipated the close of the sultry hours, who hoped for free respiration in the cool of the evening, nothing could be a greater pleasure than the rise of that star which indicated its approach; nothing could afford more general gratulation: moreover, as the inhabitants of these countries slept in the open air, on the house-tops, &c. they soon contracted an acquaintance with the stars, gave them names, perhaps had their favourites, admired their brightness, observed when such a star appeared, that flowers or fruits accompanied it, then fancied its influences, and glided into....idolatry. For let us not suppose that the human mind could suddenly fall into so shocking an-absurdity: vice must enter by degrees, put on first fair appearances, assume a pleasing guise, become an angel of light; then, gradually, step by step, gently, without alarm, without a shock, decline into its native track: but, when by habit, it has gained familiarity, and force by custom; who shall limit its excesses? Let us therefore remember, that even idolatry had at first much to recommend it, and the commencement of that evil was not apparently connected with the close.

I could heartily wish there existed among us no remains of such ideal influences of the stars; we should then no longer be pestered with predictors and fortune-tellers, and every conjuror might be *transported* as he deserved. The natural influences indeed of the sun, I allow; they are many, and powerful;

those of the moon are considerable, and undeniable. Those of the planets are by far too trivial on the whole globe, to have any effect on the fate of individuals, to rule particular parts of the body, or to dominate over such, or such, regions of the human frame.

Indeed we sometimes hear a simpleton console himself under a mischief, that "it was his ill stars, how could he help it?" But we have seen that those of the stars, whose power may be supposed strongest, (which whether hot, or cold, moist, or dry, we know not), engage their qualities in the services of their own inhabitants.

Without dependence on the stars, or fear of their malignity, let us employ our talents as rational and immortal beings, who are to be applauded or condemned by their own behaviour; let us remember, that as he who is found ultimately a wise man, will not be deprived of the reward of his wisdom, under the plea, that he was indebted for it to the stars; so the fool shall suffer for his folly, nor will it be deemed his justification, that *he* thought his fate inevitable! his ill-luck! his ill-stars! Let him lament his inattention, not the aspects of the Heavens; his ignorance, and inconsiderateness, his levity, and absence of mind; these are his real, but not unavoidable, disasters.

OF THE FIXED STARS.

IN a former discourse, we observed the very great distance of those heavenly bodies which yet we called our neighbours, and who, with ourselves, compose one system; Saturn it distant, the Georgium Sidus distant, the remoter extremes of the cometary orbits very distant;—but what are these distances to those of the stars whose splendour we behold! whose nearest estimation is four hundred thousand times the distance of the sun from us; this, I say, is the estimated distance of the nearest; there are others, very, very much beyond! How noble then are our mental powers! which not only speculate on these regions, but after multiplied additions of supposable space, feel their infinite remoteness from the heaven of heavens!

The mind surveys a star in the zenith, or in the horizon; presents itself among a system on the right hand, then (how swift is thought!) reverts to another on the left; thus it investigates space;

space : by the stars too, it investigates time ; it conceives a period ere they existed, ere one lambent flame illuminated the vast expanse ; it conceives their revolutions, their orbits, their periods, and, more than that, it awaits their extinction, and dissolution. Darkness may again envelope the spheres, and every cheering ray may cease ; yet the human soul expects to survive ; and however it may witness the expiration of all things, to itself it arrogates immortality : and justly, for the heavens shall decay, and be replaced by successors ; like some magnificent prince, who changes to-day the garments of yesterday ; so „ the Eternal as a vesture shall fold them up, and they shall be „ changed.” This sight we expect to see ;—the very idea confutes the suggestions which treat us as merely enlivened hovels of clay : no, the inhabitant and the building are different ; a breeze may overthrow this, the settling of a moth upon it may overweigh it ; but the other scorns the duration of time, and extends its existence parallel to eternity.

The distances we have mentioned, though not beyond mental comprehension, are yet exceedingly difficult to reduce to regular, or proportionate measurement ; the rapidity of a cannon ball is lost in computation ; the velocity of sound, which is double that of a cannon ball, would require four million eight hundred thousand years to reach us ; and light itself, which arrives from the sun in about eight minutes, is, during six years, travelling from one of these stars to us. So that should it please God to annihilate one of these luminaries, we should still continue, during six years, to receive portions of those beams it had previously emitted. After this observation, it seems almost needless to mention, that they at least equal the sun in magnitude, since it is open to remark, that otherwise their powers would be too weak to render them visible here. It has been thought, that our sun is a star of rather moderate dimensions ; and by no means so brilliant in appearance to some of the celestial bodies, as they appear to us. Leaving this matter thus hinted, we proceed to observe, that certainly these stars are endowed with native light *i. e.* they are SUNS ; and very probably have around them many revolving planets, whose light being only reflected, is by far too feeble to reach this residence of mortals.

A little attention discovers, that the heaven is replete with stars, and if these stars are at different distances, it is very supposable that some should be behind others ; indeed it *may* happen that the nearer should conceal the remote ; but it actually happens, in many instances, that the nearer and the remote appear so combined, as to seem but one to the naked eye, and are separable

only by the best glasses: further still, it sometimes happens, that a cluster of stars appears as one star only, and form a speck of light by their united powers: nor is the strongest instrument happy enough to shew any separation between them. We may easily conceive of this, if we consider that part of the heavens called the milky way; which is a prodigious aggregation of stars, at such small apparent intervals, as rather produces one united efflux of light, than any distinct splendour: yet, among this luminous path of the stars, a telescope discovers many and considerable intervals, as well as NEBULÆ, or UNIONS.

There are also PERIODICAL stars; which sometimes are extremely bright, sometimes scarcely visible: but which constantly preserve the same places in the heavens. Some persons account for them, by supposing half suns among the stars, or that only one part of their surfaces is fitted to emit light, the other being crufted over with spots, which, by periodical rotations are turned toward us, and from us, alternately. One hazards nothing in these regions of conjecture; perhaps some suns may move to their planets, and, at their nearest approaches to us, may be much brighter than at their furthest distances.

But there are also several stars, which, for aught we ever can discover to the contrary, are entirely NEW: I confess, it seems to me not unlikely, and we are certain it is not impossible, that Deity should be always employed in creation. On our own terrene habitation, millions of creatures are perpetually ceasing, and other millions of new-made descendants supply their places; all is mortal and perishing, but all is revived and restored; so that death, triumphant death himself, is incapable of destroying the never ceasing renovation. What therefore, forbids our supposing, that among the regions of space, divine power may ever employ its energy, in forming new worlds, and new systems of worlds?

Whether it be fact, that any stars absolutely new ever came to our knowledge; there is no doubt but several, which have been for a time extinguished (or whose light at least has been too feeble to reach us), have actually been RENOVATED: whether, by bursting the spots which covered them, or by the falling of some comet into them, which augmented their powers with fresh fuel, is beyond our determination.

The stars themselves are wonderful luminaries; but what shall we say to those SPACES in the firmament, which are RESPLENDENT, yet without stars; and which seem to be vast expanses of light! If they have inhabitants, they enjoy perpetual day, and never know obscurity or darkness. Are we permitted to view these spaces, as exemplars of that perfect glory we are taught to expect?

expect? Are they residences of blissful spirits? — Are they — but by what principles shall human knowledge answer? We confess our ignorance, and adore in silence.

If there was no utility connected with the stars as seen from the earth, their magnificence and vivacity would excite admiration; but, besides the advantage a knowledge of them affords us on sundry occasions, whereby we ascertain many useful facts, there is in particular one, the POLE-STAR, to which we are beholden for almost all the facility of our navigation. This star, by being situated in that part of the heavens to which the north pole of the earth points, performs the office of a director and guide, to those who, on the mighty waters would be unable without it to determine their proper course. For it is evident, that if a vessel keeps any certain and fixed point, to the right hand, or to the left, it must greatly contribute to ascertain the course it pursues; such a point is the pole star: ever remarkable, and not less so since the happy discovery of the magnetic virtue, which points the compass to the Pole.

What obligations are we not under to that noble and powerful invention, the Telescope! by whose assistance we become acquainted with the preceding facts: how many thousand objects has it discovered, which to human eyes were formerly invisible! In the constellation Pleiades, commonly termed the Seven Stars, have been seen at least seventy stars. This may hint a caution to us, when reasoning on subjects beyond our powers: there exist many principles, and causes, not to be discovered without what may be termed *telescopic* assistance.

This magnificent firmament, decorated with stellar fires, has ever been a favourite study of mankind: it is true, the day is the time for activity and diligence; man is therefore engaged to pursue his business by a flood of light poured forth around him, and few inducements divert his attention: but that none of his time may be waste, even in the periodical absence of the moon, the stars attract his contemplation, and direct upwards his attention, his views, and his desires.

The whole of what we see is probably but a part of the great, the universal system:—whether we are in its extremes, or nearer its centre; whether its centre be the beatific presence, around which circulates the whole; or whether our appointed heaven be nearer our abode, we know not: but we know, that Deity is every where; equally visible by the operations of his power, on our own globe, in our own country, in our own persons, as if this was the only district of his dominion, and his peculiar residence was among the sons of men.

We

We have now completed our Survey of the Celestial Phenomena ;—when subjects of importance, and magnitude, engage our attention, it is necessary, not only to inspect them part by part, but to consider the general result, the *effect* of the whole : thus some magnificent edifice, not only delights and pleases by its ornaments and decorations but, by the symmetry and proportion of its parts, by united elegance and greatness, it commands admiration and applause. Such is the effect of the heavenly phenomena ; each in his orbit is interesting ; each in his orbit proclaims the power and wisdom which appointed it ; each in his orbit exemplifies Almighty skill, and obeys Almighty direction, ever found in his station, and freely performing his course, in profound submission to its divine author's original *fiat*, and continued impulse.

The result of the whole, is the most august chorus of praise, of which mortals can form any conception ; and, indeed, in order to form a conception (imperfect as it is) of this combination, we are obliged to use every art, and to summon all our powers. We begin with an instance most obvious, and proximate ; we rise from this to a second, from a second to a third, till we visit tracks of light. Such is the progress we have pursued : our appointed luminary assisted our ideas of luminaries almost infinitely remote ; our native system supported our guesses at systems beyond our inspection ; and our planetary chorus aided our ideas of that general, that universal chorus, that system of systems, whose combination affords perpetual meditation and reflection. Yet, after all which can be said on the contrivance of worlds ; after all our remarks on the wisdom evident in their formation, and the skill manifest in their construction, one adoring thought in the human mind, one effort of rising gratitude, one ejaculation of genuine praise, is infinitely superior in value to all their splendour. Actuated by no principle of love, but impelled by power, excited by no desire of acceptance, but obedient merely as revolved, they neither esteem, nor adore, nor praise, (but passively) their omnipotent Author ; let then those who can actively esteem, admire, and adore, supply their deficiency. These heavenly objects call, and with no feeble voice, on every power of our minds, and excite to such duty every principle of reason, reflection, and thought.

Reflective adoration is not only the most proper and direct, but also the most beneficial employment of our faculties ; it requires not depth of study, unweariable continuance of observation, life-long engagement of attention and remark ; yet is unquestionably certain of divine success and acceptance.

If,

If, on many occasions during the progress of these discourses, we have had occasion to acknowledge our ignorance, to own that the works of Deity are beyond our conception, with what humility should we think and speak of DEITY itself! The whisper of his ability we hear, but the thunder of his power who can tell? A ray of his splendour we discern, but what is the weight of his glory? A span repletes our limited faculties; if we extend our ideas beyond subjects with which we are intimate, we quickly feel a memento which advises us, that moderation is wisdom. Though we conceive a period anteceder to the stellar fires, though we await the close of their existence,—and thus conceive of duration; though we add to regions of constellations other regions beyond them, roving in idea through realms of splendour,—and thus conceive of space; by all this, what advance have we made toward conception of HIM, to whom all time is NOW, and all space a POINT!



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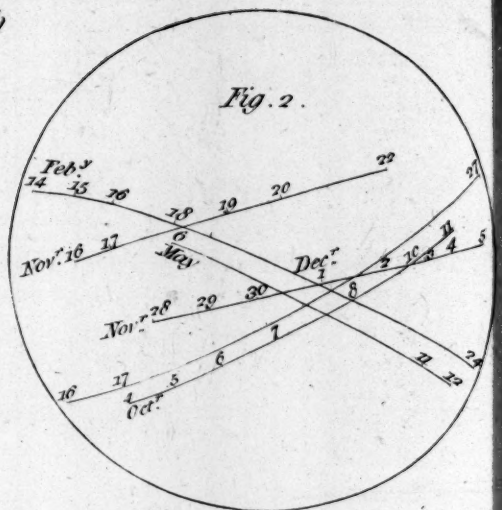
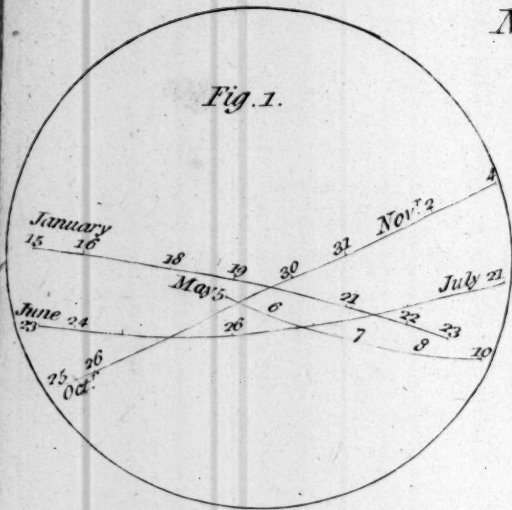


Fig. 5.



Fig. 6.

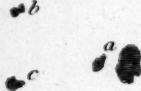


Fig. 7.

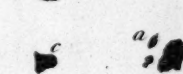


Fig. 8.



East

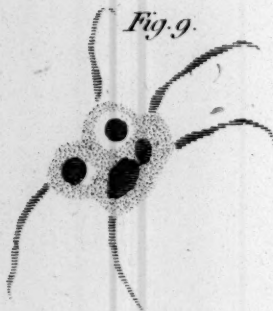
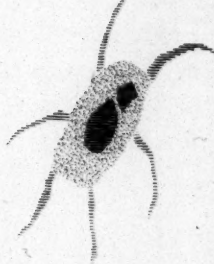


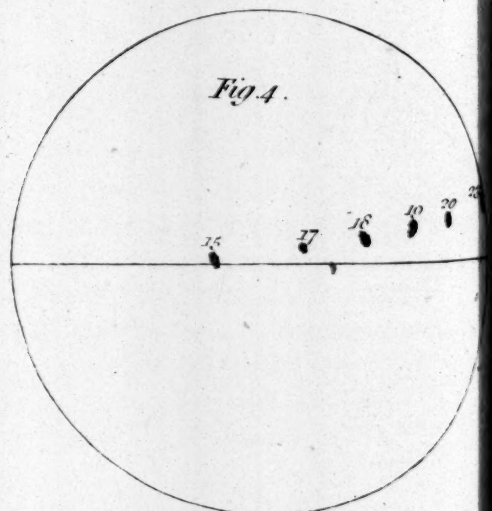
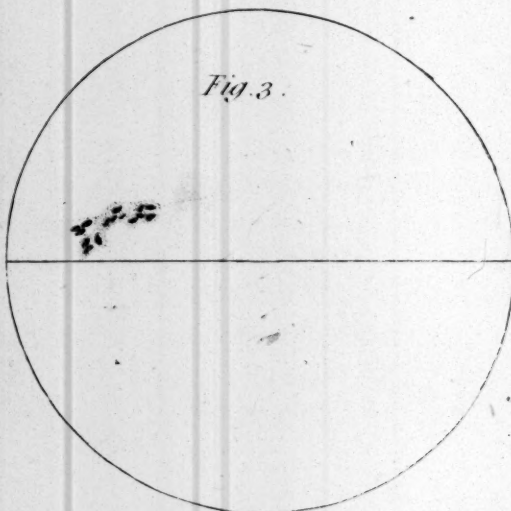
Fig. 10.



West



SOLAR SPOTS.



South

OBSERVATIONS ON THE PLATES.

PLATE I.

SPOTS IN THE SUN.

THE figures of this plate shew the various and uncertain forms assumed by the solar spots, and their perpetual changes.

Fig. 1. and 2. Represent the general path of the SOLAR SPOTS; from whence it appears, that they mostly keep about the middle of that globe, seldom appearing near to either his north or south extremity; but, though not uniform in the lines of their progress, yet on the whole, observing a general path.

Fig. 3. Represents the course of a cluster of small spots: They move freely in every direction, which demonstrates that they are immersed in a fluid, not fixed in a solid body. Their continuance, as well as their forms, is extremely uncertain; the longest duration observed has been seventy days: but sometimes they last scarce twenty-four hours.

Fig. 4. Shews a single well-defined spot; we observe that in conformity to the principles offered, the daily interval decreases as the spot quits the centre: from twenty to twenty-three, being scarce the distance from seventeen to eighteen, agreeable to what would be the appearances of such an object on a globe.

Fig. 5. A spot seen on the sun, June 27, 1703, at between nine and ten o'clock in the morning: wherein we observe, *a* is a triangular spot accompanied by two lesser ones, *b* and *c*.

Fig. 6. The same spots seen at four o'clock in the afternoon of the same day: *a* appears to have lost its triangular shape, and a fragment is broken from it; *b* is become thinner, and *c* is augmented in dimensions.

Fig. 7. The same spots at half after five o'clock: the fragment from *a* is itself divided into two, the spot *b* is become very narrow, and scarce visible.

Fig. 8. At half after six o'clock, the spot *a* broken into another fragment; *c* much enlarged.

A

Fig.

Fig. 9. The spot *a* seen the next morning about seven o'clock, very greatly varied in form, and a new spot below it at *b*.

The same at ten o'clock: the spot *b* augmented in bulk, and a small spot additional.

Fig. 10. and 11. Spots surrounded by a yellow mistiness, from whence issue rays, which give them almost a spider-like appearance.

Fig. 12. The same spots further varied.

Fig. 13. Are spots surrounded with nebulæ (or cloudiness): the spot *b* appeared sometimes very black, sometimes fainter: *c* and *f* seemed like smoke, varying in strength, appearing and vanishing often; *b* disappeared first: *a* remained some time longer, perpetually changing its form and strength of colour.

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PLATE II.

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VIEW OF PART OF THE MOON, IN HER
FIRST QUARTER.

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PLATE III.

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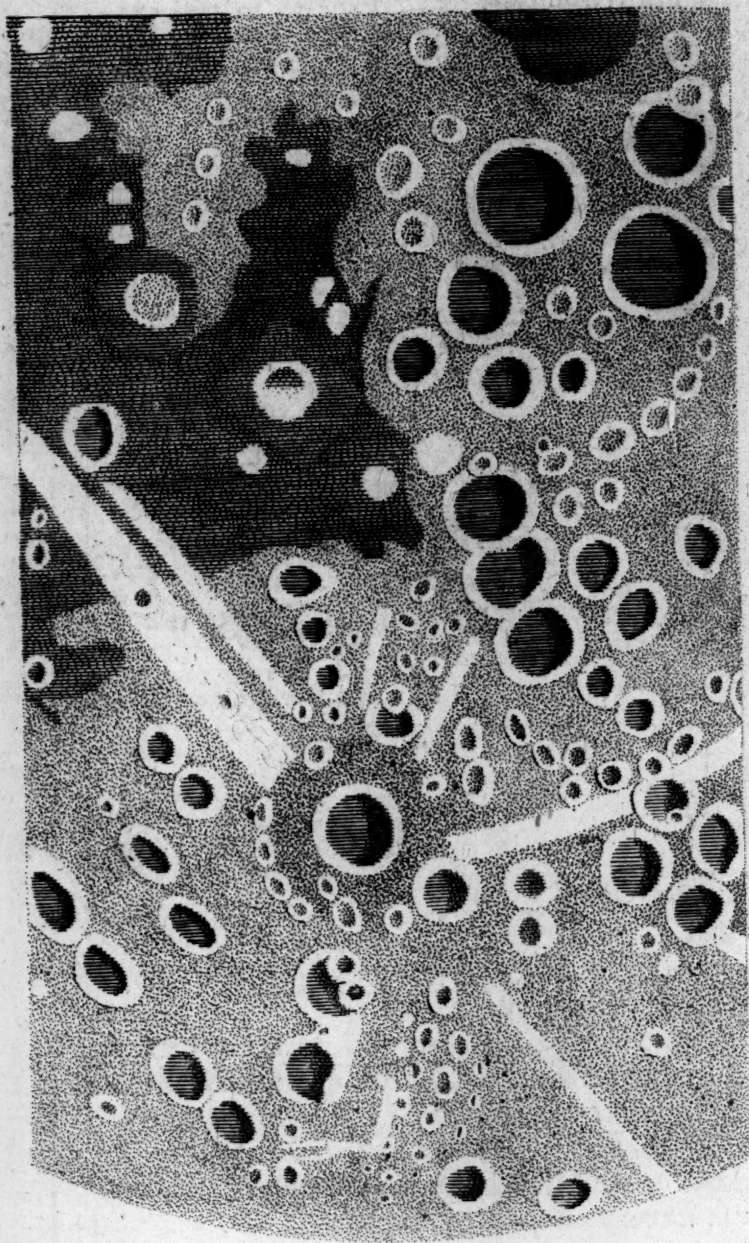
VIEW OF THE SAME PART OF THE MOON, IN HER
THIRD QUARTER.

WE observe that the shadows of these parts fall contrary ways, at these different times, they seem also to fall into cavities and pits: the white ridges apparent on the lunar surface are certainly risings and hills. Whether the larger shaded portion be water: we can only conjecture.

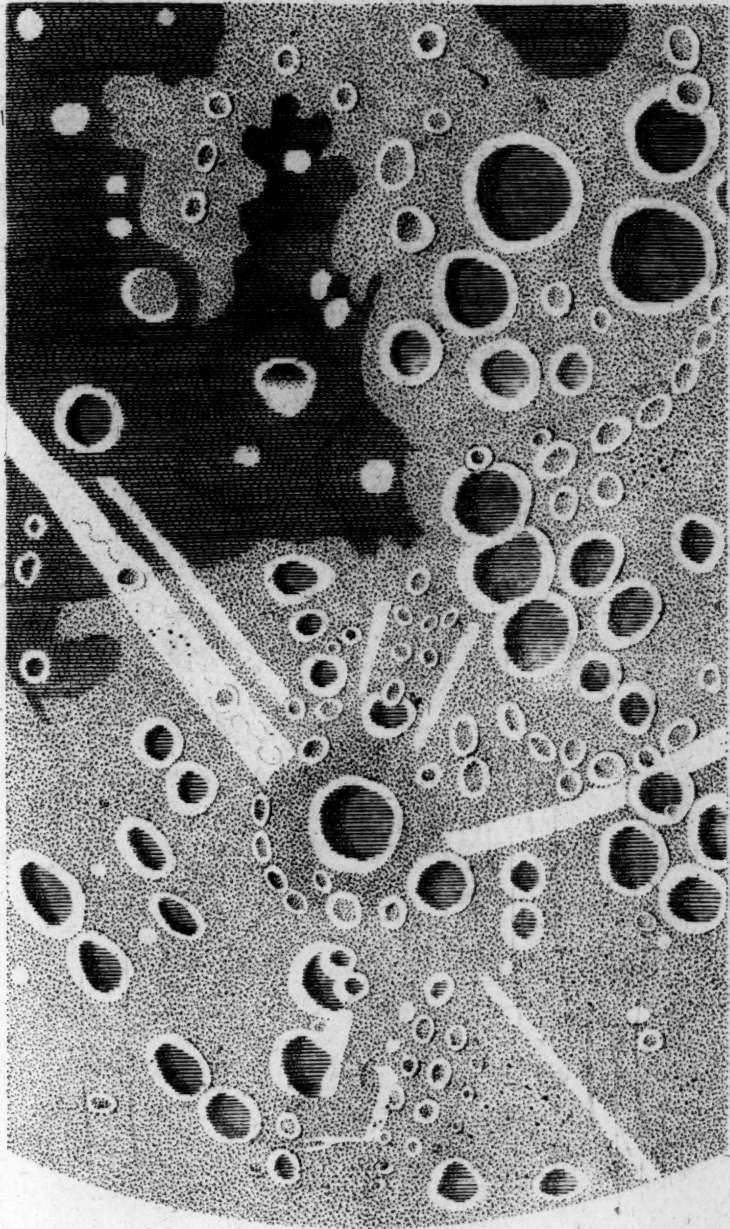
PLATE



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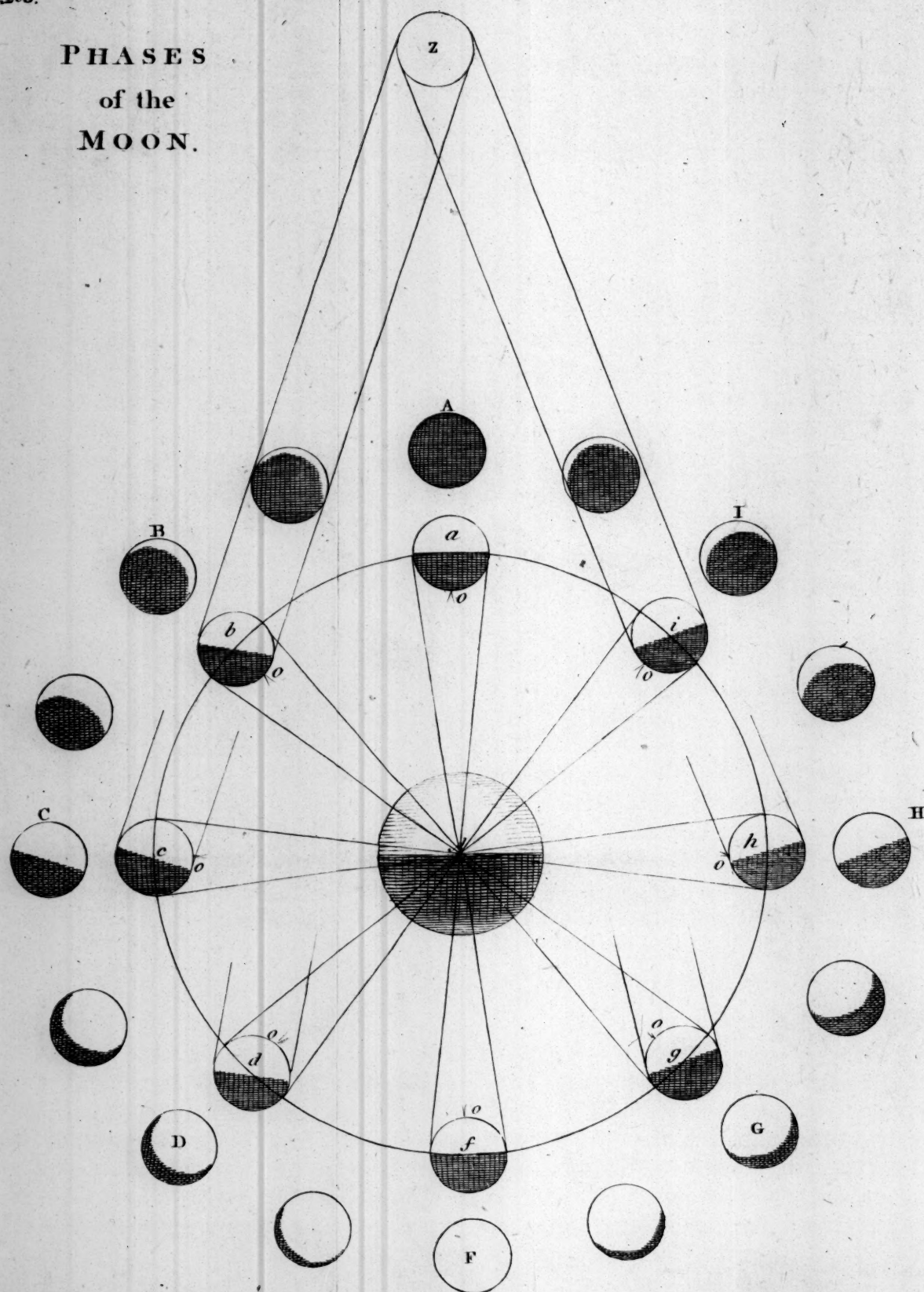
Part of the Moon in her first Quarter.



Part of the Moon in her third Quarter.



PHASES of the MOON.



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PLATE IV.

EXHIBITS the PHASES of the MOON, as shewn to the earth during one rotation.

The truly proportionate distances of the heavenly bodies from each other, are by far too immense to be regarded in these kind of explanatory figures; for it is evident, that were the sun (S) any thing like an adequate proportion to the earth (E) in size, or in distance, the earth, &c. must have been almost invisible by its smallness, or the sun must have been very far beyond the limits of the plate.

In this example the earth (E) is supposed at rest, while the moon circulates around it, according to the order of the letters. The eight smaller letters, *a, b, c, d, f, g, h, i*, shew the relative situations of the moon to the earth during her course; the larger letters, A, B, C, D, F, G, H, I, shew what proportion of the moon is seen *enlightened*, from the earth. We observe, that the light begins by a slender streak on the right hand, or western limb, at (B), which increases to half at (C), and to the full moon at (F); from whence it decreases, and takes the left side of the moon, or eastern limb, at (H), till it again becomes a slender streak, at I.

It appears, by fixing on any one part of the moon's surface, as at *o*, that during her whole revolution she turns but *once* on her axis—that she has but one day, and one night: as at *a*, *o* is midnight: at *b*, *o* advances toward day-break; at *c*, *o* is early morning; at *f*, *o* is high noon; at *h*, *o* is afternoon; at *i*, *o* is night. It appears also, that the same part of the moon is constantly directed toward the earth; as is clear by tracing the marks at the letters *o, o, &c.*

PLATE V.

ORBIT OF THE MOON, AND ECLIPSES.

WHATEVER may be the true station of heavenly bodies, the eye estimates them as at one uniform distance ; so that however remote S 1, S 2, S 3, S 4 (the sun), may be really, yet it appears as if close to the moon : its station is therefore in this example transposed, and its course is *supposed* to be round the earth (E), which is *considered* as at rest.

We note first, that the *apparent* orbit of the sun, and that of the moon, (M 1, M 2, &c.) are not of equal height, but M 1 M 2, M 3, &c, is supposed to be in one part of its course *below* and in the opposite part of its course *above* that of the sun, and only to coincide with it in two points, M 1 and M 7, which are termed **NODES**. This principle is illustrated by two hoops of equal size, one put within the other, and somewhat lowered at one part ; the opposite part *will* be heightened, and it will touch that hoop which surrounds it, *only* in two opposite points, where it may be said to form a knot, or node ; one of which may be called, in reference to the course of such a hoop, descending, the other ascending. When the moon is coming north her *Node* is termed the *ascending Node*, when going south the *descending Node*.

It should be observed that the moon's nodes (M 1.) are *retrograde*, and will not return to this point again till nearly nineteen years are expired : but will be continually changing place throughout the signs, at the rate of nineteen degrees yearly, meeting the sun every year nineteen days *sooner* than the year before.

This premised, we observe, that there being no intercepting body between S 1 and E, E enjoys the whole of the light coming from S 1 ; but between S 2 and E, the node of the lunar course happening to fall, so soon as M 1 is arrived at its node it begins to intercept the light, (and to conceal part of the body) of S 2 from
E,

ECLIPSES

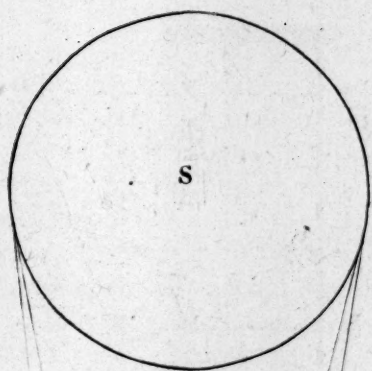


Fig. 1.

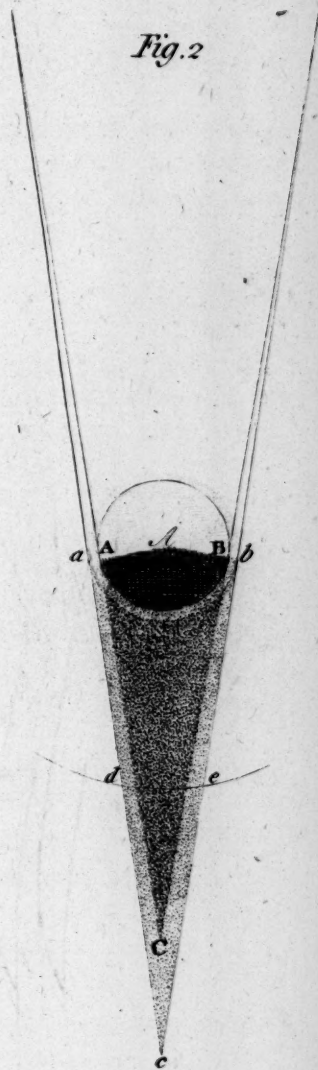
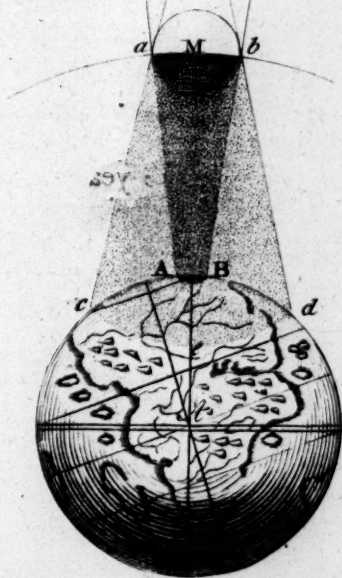


Fig. 2.



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E, and this it continues to do during so long time as S 2, M 1, and E, are in a *perfectly* straight line. This as has been noticed, can only happen at new moon; a total eclipse of the sun, it is evident, therefore, by the figure, can only happen when the moon is new in her node.

If we suppose, that in some other revolution of the moon, she is new at some little distance from her exact node, as at M 2, she will then eclipse only such a part of S 3 (whose place as before is transposed) as is proportionate to her distance from her node: also, if her course be descending, she will conceal the lower part of S 3. If in another revolution she is new at M 3. she will just touch S 4. but very slightly; as at M 4. she is too far below the sun to conceal any part of him.

The limits of solar eclipses extend to seventeen degrees from the moon's nodes: *within* that space, the sun may be eclipsed; *without* that space, the moon is either too high or too low for any part of her shadow to fall on the earth, as at fig. 3. When the sun is more than twelve degrees from the node, the moon is generally too high or too low to go through any part of the earth's shadow.

Precisely the same principles explain the remaining figures on this plate. It being supposed that in one revolution of the moon she is FULL at M 5; it follows, that she is so far distant from her node, as to be barely touched by the shadow of E. In another revolution, being full at M 6, she is deprived of great part of her light; but when she is full in her node, at M 7, she is totally immersed in the shadow of the earth, not only while she remains in her exact node; but for so long time before and after, as she takes in passing through the shadow of the earth; during which time the lunarians are deprived of the light of the sun. These eclipses happening during the *ascending* node of the moon, her *upper* part is eclipsed in consequence.

On these plates the shadows are distinguished from the objects, by being engraved in stippling, for the sake of perspicuity.

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PLATE VI.

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PARALAX AND ECLIPSES.

Fig. 1. PARALAX.—There is scarcely any person who has not observed, that by looking at an object, first with one eye only, then shutting that, and looking at the same object with his other eye the apparent place of the object is changed with regard to others behind it; and this is most observable when the object is near, and its back-ground distant. Much the same is the effect of paralax with regard to the sun, planets, &c. but especially with regard to the moon, she being so near to us.

If the earth were transparent, and a spectator supposed at A, the center of the earth, he would see D and *e* in the same line, forming one object; or, if he looked towards M, he would see M and Z C forming but one object; or if he looked perpendicularly, *z* and Z would form but one object, But on the surface of the earth, this would take place only in certain parts; *i. e.* where a straight line drawn from the object would reach to the center E.

For example; to A, *z* and Z are in the same station, but when A looks toward M, it does not correspond with the station of S, but is seen *adjoining* to it at *m*: this effect is yet greater in the horizon, where D is not seen by A at *e*, but at *d*. So that while to B the object M covers Z C, A will perceive no such event. The application of this to eclipses is evident, for if Z C be supposed a luminary, and M be an opaque body, Z C will be eclipsed to B, but not to A.—Paralax at the horizon *lowers* an object one degree of the circle, as from *e* to *d*, but its effect continually decreases in advancing toward the zenith, so that it is barely half a degree at B, and at A it is nothing.

Fig. 2. 3. 4. Shew more at large the instances of the Moon's shadow falling on the Earth, in so many different revolutions of the

ECLIPSES

Fig. 1

Parallax.

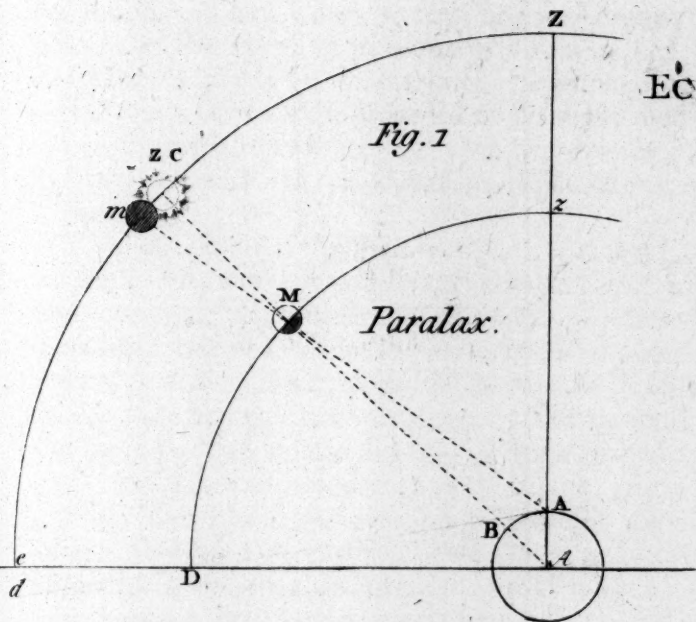


Fig. 2

Moon's Orbit

Earth's Orbit

Fig. 3

Fig. 4

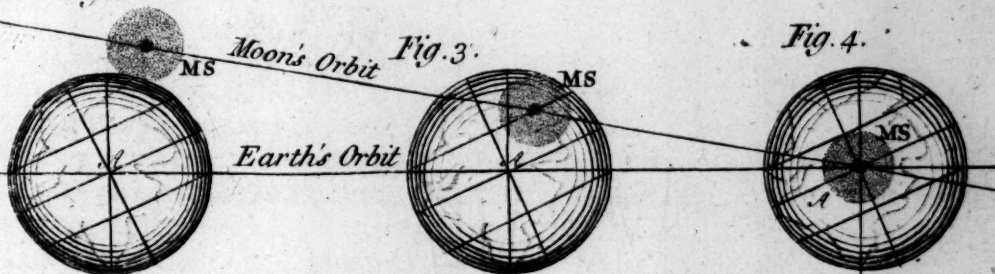


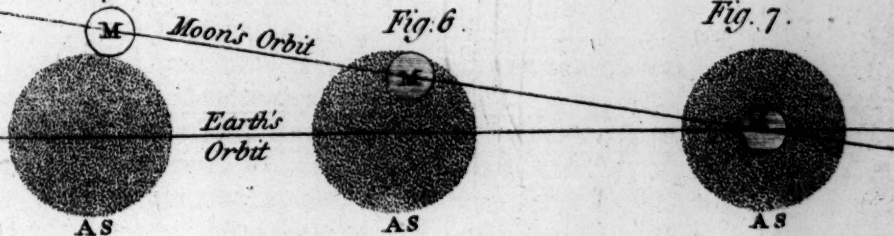
Fig. 5

Moon's Orbit

Earth's Orbit

Fig. 6

Fig. 7



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the moon. They are to be regarded as so many PLANS of the shadow of the moon at so many new moons. A the earth, MS the Moon's Shadow; throughout the whole of the figures.

Fig. 2. The moon supposed to be new; but so high above the earth (seen from the earth) that her shadow passes over it so as just to touch the circumference of the earth, making no eclipse.

Fig. 3. Plan of the shadow of a new moon falling completely on the earth, where we observe, that in some places the eclipse will continue a considerable time, *i. e.* where the shadow is broadest; but at the top and bottom of the shadow, it will be scarcely visible, ere it be passed over. We observe also, that in the very center of the shadow, it will be total; the whole of the sun's body being hid from a spectator placed in the little black spot, which corresponds with AB, fig. 1. plate VII.

Fig. 4. The node corresponds with the center of the earth. It will therefore be a total eclipse at the equator, where the sun is vertical, but it is no eclipse in many parts of the globe.

Fig. 5. 6. 7. Are so many plans of the passage of the earth's shadow at the time of full moon. M the Moon, AS the Earth's Shadow.

Fig. 5. The moon so high above the earth's shadow at the full, as to pass, just touching the earth's shadow:—no eclipse.

Fig. 6. The moon at full, nearer to her node, totally eclipsed; but the upper part of her only for a very little time.

Fig. 7. Full moon at the node: therefore a total eclipse, of so long duration, as the moon takes in passing through the shadow of the earth.

The superficies of the sun, and the moon, being considered as divided into 12 *digits*, or parts, each: the mode of estimating the quantity of an eclipse is, to say, so many *digits* (8, or 10, &c.) are eclipsed: When an eclipse is barely total 12 *digits* of the luminary are eclipsed. The sun can be eclipsed but little more; but the moon may be eclipsed 20 *digits*; *i. e.* not only her whole surface may be in shadow, but it may continue in shadow, so long a space as equals 20 *digits*.

The longest duration of a total eclipse of the sun, *i. e.* of total darkness, is less than four minutes: but the eclipse may continue partial, two hours, and a quarter.

The longest duration of a lunar eclipse, is when the earth is in aphelion, and the moon in apogee: 3 hours, 57'. 6"

Annular eclipses are, when the moon appearing somewhat less than the sun's body, (and their centers perfectly coinciding); she suffers the brightness of the circular outline of the sun, to shine all around her: an extremely curious sight, indeed!

PLATE

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PLATE VII.

.....

ECLIPSES.

Fig. 1. ELEVATION of an eclipse of the sun. S the Sun, M the Moon, A the Earth.

We observed, that the sun, being immensely larger than the moon, occasions *two* kinds of shadow from the moon: one a real and total privation of light; at the moon itself, of equal breadth with its diameter, $a\ b$, but decreasing at a distance from the moon; and ere it reaches E, very much narrowed, as at A B. The second kind of shadow is merely a partial privation of light; For M being so much smaller than S, can only conceal part of S, consequently the other parts of S continue still to impart light: this is termed a *penumbra*. It is evident, that wherever the total shadow AB takes its course, there is a total eclipse. This answers to the black spot in fig. 3. 4. plate VI.

Fig. 2. ELEVATION of the shadow of the earth during an eclipse of the moon.

We observe, not only that the shadow narrows at a distance from A, but also, that much of the shadow which actually reaches $d\ e$ (the moon's course), is that of the atmosphere round A, which extends to c , while the shadow of E terminates at C; the diameter AB is augmented by the atmosphere to $a\ b$, whereby the shadow is enlarged; but on the other hand, the refractive power of the earth's atmosphere is so great, and it inflects the rays of the sun so strongly into itself, that the *pure* shadow of the earth extends less than 40 semidiameters of the earth; and is greatly attenuated before it reaches the moon, having many of the solar rays intermingled with it. More than half of E is enlightened by the Sun, AB being much below the center E.

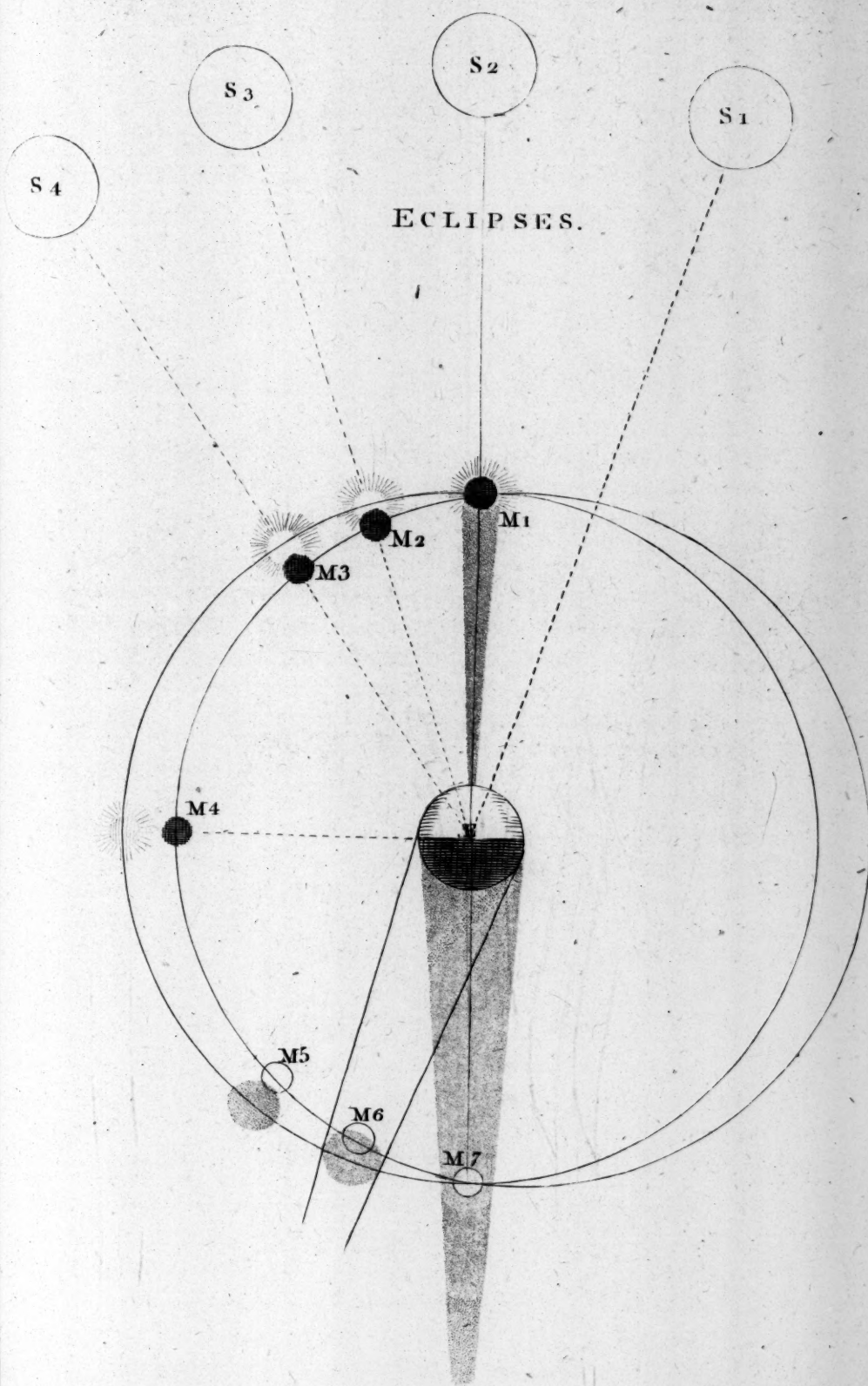




PLATE 1. THE BIRD

1870



CHARACTERS of the SIGNS

Aries



Taurus



Gemini



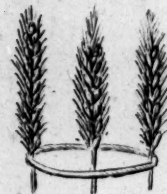
Cancer



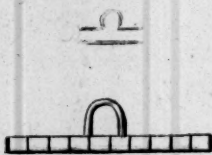
Leo



Virgo



Libra



Scorpio



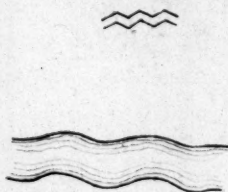
Sagittarius



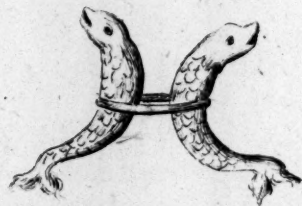
Capricornus



Aquarius



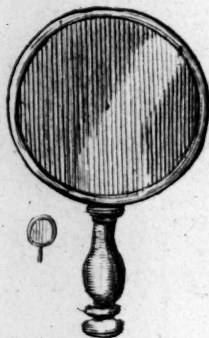
Pisces



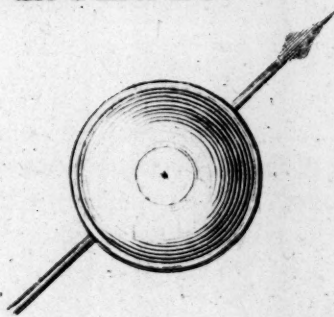
CHARACTERS of the PLANETS



Mercury



Venus



Mars



Saturn

.....

PLATE VIII.

.....

CHARACTERS OF THE SIGNS.

THIS plate shews the resemblance of the original representations of the signs of the zodiac, to those animals whose names they bear: it shews also their depravation into the characters now used by the hasty copies of transcribers, or by unskilful drawings. The signs are always reckoned in the order here placed.

(I.) ARIES, the ram's horns, now marked γ .

(II.) TAURUS, the young bull's head now marked δ .

(III.) GEMINI, or the twins: this sign is supposed to have been originally the two kids, and is often marked by a character taken from two goat's heads butting each other; but as the custom of referring it to the human species is very ancient (perhaps as the time of deification of Castor and Pollux), it is here retained. The mark Π is taken from the grecian symbol of those deities. The caps on the heads of these boys, are also proper to Castor and Pollux.

(IV.) CANCER, the crab, is here composed of the tail of a crab, or fish of that kind, and the head of the Egyptian Ibis. Dr. LONG thinks this character meant originally merely to signify the change of the sun's declination from north to south, by the two lines drawn contrary ways, ∞ .

(V.) LEO, the lion's tail, drawn tolerably resembling to its original. Ω .

(VI.) If astronomers were such ill draughtsmen as to disfigure the foregoing signs it is no wonder they omitted the figure of VIRGO (the Virgin), and substituted the three ears of corn tied together, which she holds in her hand; we could however have wished, that the current character of this part of this sign had better expressed what it professes to represent m .

(VII.) ♎ LIBRA, is clearly the balance.

(VIII.) SCORPIO, is drawn m ; representing the claws and tail of this animal: as his sting is in his tail, its dart-like termination could scarce fail of distinction.

B

(IX.)

(IX.) SAGITTARIUS, the archer ($\uparrow$); himself omitted, for the same reason as Virgo, but his arrow inserted (sometimes also his bow, or part of it) as more facile of representation.

(X.) CAPRICORNUS, the wild goat; differing pretty much from a tame one, by his hinder part terminating in a fish's tail; perhaps this union is not foreign from the occupation of the early nations, *i. e.* hunting the wild goat, as well as fishing in this month. The first character is clearly derived from this figure; the character is $\wp$ by no means so authentic, nor, except in England, so general.

(XI.) AQUARIUS, $\asymp$ expresses well enough streams of water whether floods or rains.

(XII.) PISCES, ($\times$) is evidently derived from two fish, tied back to back.

CHARACTERS OF THE PLANETS.

(I.) The character of the SUN $\bigcirc$ (a circle) seems to be merely a delineation of this glorious center of the system; The character $\odot$ (a circle with a knob in the middle) imitating a buckler, has been attributed to the sun; so has also a cone. But a circle seems greatly preferable.

(II.) D the character for the MOON, descriptive of her appearance when partly enlightened.

(III.) MERCURY is signified by the caduceus ($\wp$), an attribute constantly attendant on the heathen deity of this name.

(IV.) VENUS is expressed by (ϕ) a mirror with a handle; aptly hinting the personal attention of the goddess of beauty. The ancient mirrors were made of polished brass.

(V.) MARS (♂) a spear and shield; as god of war.

(VI.) JUPITER (♃) the first letter of his Greek name (Zeus) with a stroke of abbreviation.

(VII.) SATURN (♄) a sickle; originally a scythe, which refers to his Greek name *Cronos* (Time), whose effect is, to cut down all things without remorse.

(VIII.) The earth is marked by a circle with a line across it.

(IX.) The character adopted at present for the Georgium Sidus (Mr. HERSCHEL's discovery) is an H with a globe pendent from the middle of the cross stroke.

SOLAR SYSTEM.

A.D. 1666. Period 120 Years

1680 Period 57 1/2 Years

Perih

Aph

Jupiter

Saturn

Earth

Mars

Venus

Mercury

Moon

Perihelion

Aphelion

Georgium Sidus

ORBITS of the PLANETS

a, Mercury. b, Venus. c, Saturn. d, Mars. e, Jupiter.

a, Mercury. b, Venus. c, Saturn. d, Mars. e, Jupiter.

a, Mercury. b, Venus. c, Saturn. d, Mars. e, Jupiter.

.....

PLATE IX.

.....

THE SOLAR SYSTEM.

THIS plate comprises as complete a view of the solar system, as perhaps can be contrived on one plate. It is to be considered as containing,

(I.) A PLAN of the orbits of the planets composing the solar system.

(II.) The PROPORTIONS of the planets to the sun.

(III.) An ELEVATION of the orbits of the planets, supposed to be seen from the sun.

(IV.) The places of the NODES of the planetary orbits, with the orbit of the earth.

(V.) A specimen of the contradictory orbits of comets.

(I.) In the centre of the system is the sun; around whom revolve (1.) MERCURY, whose orbit is at one time much farther from the sun than at another; the thin line denoting a really circular course, the black line the actual course of this planet. His *aphelion* and *perihelion* are very evident.

(2.) VENUS, whose orbit is nearly circular; the aphelion part of it, therefore, only denoted by its stronger blackness.

(3.) The EARTH, whose orbit is also nearly circular; its aphelion marked *a*, its perihelion *p*.

(4.) MARS, whose orbit has considerable eccentricity; his actual course distinguished by its strength.

(5.) The orbit of JUPITER.

(6.) The orbit of SATURN distinguished on the same principle.

Of the GEORGIUM SIDUS, the seventh planet, we have only hinted a notice. His orbit exceeds twice the distance of Saturn; and if truly laid down, would have diminished the courses of the inferior planets, so as to have rendered them very small. We have therefore preferred inaccuracy in the place of this orbit to confusion in all the others.

All the planets move the same way; and seen from the sun appear to go round him (as the sun himself revolves) from right to left; according to the order of the letters marked on the orbit of Jupiter, *a, b, c, d, e, f, g, h, i, k, l.*

Around these orbits are placed the characters of the twelve signs and their degrees; these serve equally to all the planets, so that as well Mercury, as Saturn, is said to be in a particular sign, when seen from any station he appears among the stars which compose that sign.

N. B. *The degrees of the signs are reckoned from sign to sign, each containing thirty degrees: and not from any specific point, continued throughout the circle.*

(II.) The proportion of the planets to the sun, appears by a comparison of them with the line S S; which represents the diameter of the solar orb.—The real dimensions of these bodies have been noticed.

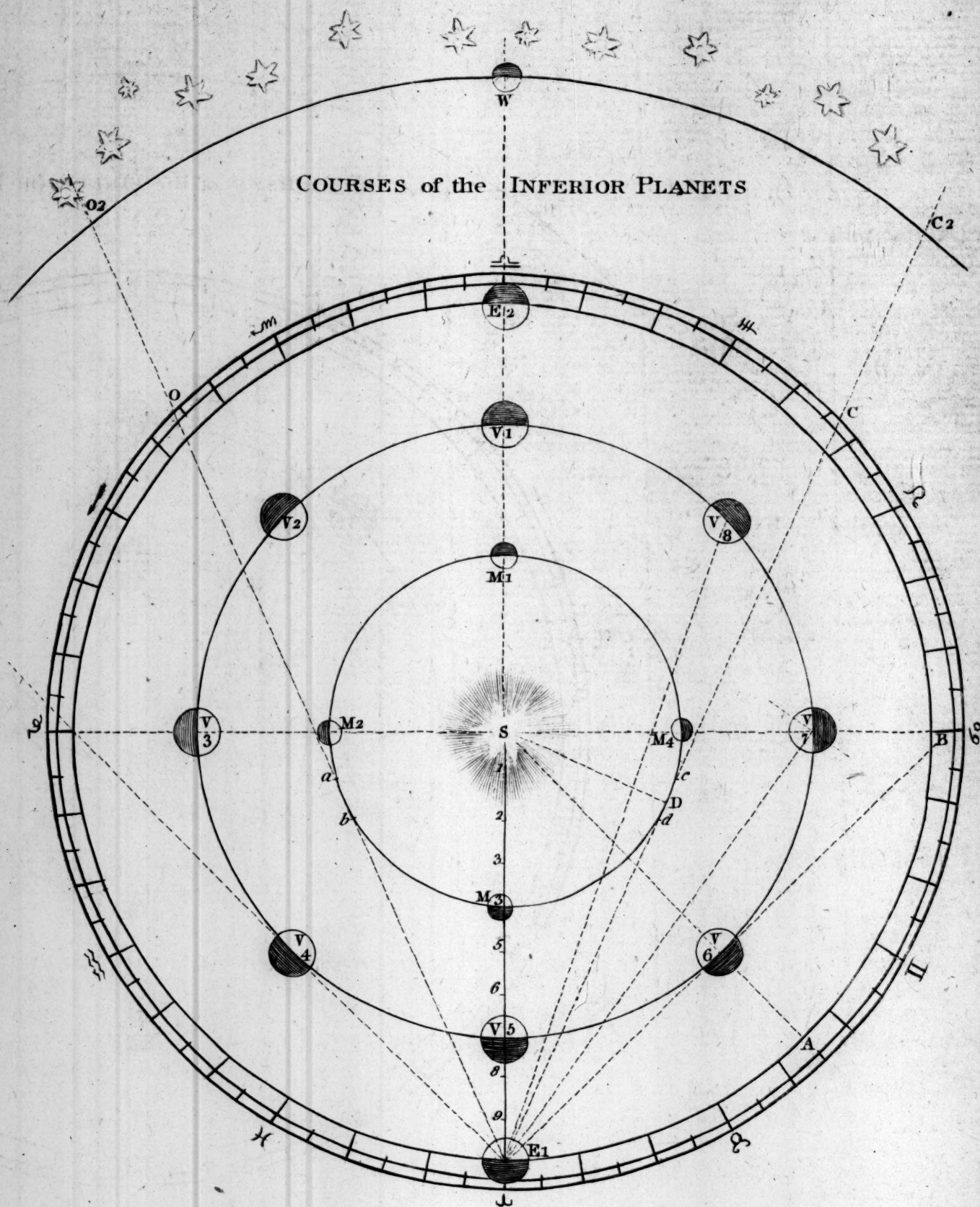
(III.) ELEVATION of the orbit of the planets, as seen from the sun: these are estimated by comparison with the orbit of the earth, from which the orbit of Mercury differs more than that of any other planet; and is therefore at once the smallest, and the most irregular,—as his eccentricity is greatest, and—as the elevation, and depression of his course is also greatest. The orbit of Jupiter differs but little from that of the earth. In fact, with regard to what differences *might* have existed, the whole of the planetary courses may be regarded as nearly similar. The quantity of variation from the ecliptic is, as follows:

Mercury	6°	59'	20"	Jupiter	2°	20'
Venus	3	23	5	Saturn	2	33 30
Mars	1	52				

(IV.) As the foregoing figure is under a necessity of supposing (what is false in fact), that the courses of the planets cross each other [*i. e.* form knots or nodes] in the middle of the elevation, it is the design of the thin lines, marked with the names of the planets, to correct this idea; accordingly, by attending to them, it appears, that the intersections of the planes of the planetary orbits with that of the earth, *i. e.* their nodes [such planes supposed to be extended so as to meet the earth's orbit], are as follows.

14° 43'	The ascending node of Mercury in	♈ (Taurus)
13 59	of Venus in	♊ (Gemini)
17 17	of Mars in	♈ (Taurus)
7 29	of Jupiter in	♋ (Cancer)
21 13	of Saturn in	♋ (Cancer)

The



The descending nodes are of necessity diametrically opposite to the ascending, and are marked on the plate by the names of the planets at length.

(V.) This plate exhibits also tracts of three COMETS, as specimens of the liberty with which these bodies advance toward the sun on all sides: sometimes from the right-hand, sometimes from the left; sometimes ascending from below, sometimes descending from above. We remark that such courses as are most round, are most speedily terminated; while such as are very narrow, and almost are as it were parallel, are of very long duration. The number of comets is great; but these cases are selected as being most contradictory.

The computation of the planetary distances assumed in page 175 is much below the truth; but, as it was esteemed sufficient for general purposes, it was not changed. More accurate estimations consider the mean distance of

MERCURY	to be 36,841,500 miles say,	in round numbers	37,000,000
VENUS	68,891,500	say,	69,000,000
THE EARTH	95,173,000	say,	95,000,00
MARS	145,014,000	say,	145,000,00
JUPITER	494,991,000	say,	495,000,00
SATURN	907,956,000	say,	908,000,000
GEORGIAN	1,900,000,000		

.....

PLATE X.

.....

COURSES OF THE INFERIOR PLANETS.

IN this diagram, the earth (E 1) is supposed to be at rest, while the planets Venus (V) and Mercury (M) perform their revolutions. The distance from the sun (S) to E 1 is divided into ten parts: at the fourth part is placed Mercury, at the seventh Venus. M 1 shews Mercury in conjunction with S, from whence he rapidly advances towards M 2, where he is distant from any interference of the solar rays; so far he appears DIRECT in his course: as he advances to *a*, his pace slackens, and from *a* to *b* though he really moves, yet to E 1 he appears without

without motion, *i. e.* STATIONARY: from *b* to M 3, his course seems to E 1, to return back, from O toward M, and $\simeq$; *i. e.* contrary to the order of the signs, or RETROGRADE: at M 3, he is again in conjunction with S, and continues retrograde till he arrives at *d*, here he seems stationary while moving from *d* to *e*; where he again becomes direct in motion to M 4, and so continues to the end of his course in M 1.

In the same manner V 1, V 2, V 3, to V 4, is direct in motion; at V 4, stationary, (in *vs* among the signs) from V 4 to V 6, retrograde, stationary at V 6, and from thence again direct.

With regard to the more or less enlightened appearances of these planets, it is clear, that at V 1, the whole of the illuminated part of the planet is turned towards E 1, but the superior blaze of light transmitted by S, entirely over-whelms its brightness. At V 2, though much of its light reaches E 1, yet beside being in the neighbourhood of S, it is by very much further distant from E 1 than V 3 or V 4. Add to this, that in V 4 it is seen by E 1 as if further from S, than in any other station, and a line drawn to any other station (as V 7), must of necessity approach toward S. At V 4, therefore, or perhaps, more precisely somewhat nearer to V 5, its light is most splendid; and in this situation, Venus is a most glorious star, her light is even strong enough to be seen in the day-time, and at night to cast a shadow from objects properly situated. At V 5, the dark side of the planet is turned toward E 1, so that E 1 cannot expect her now to be visible. At V 6, as at V 4, she is extremely bright, although barely half her enlightened hemisphere be visible to E 1, as appears by the line S A. At V 7, three quarters of her enlightened hemisphere is visible; but she shines not so bright as at V 6, for reasons already given, *viz.* her distance from E 1, and her apparent approach toward S.

The figure also evinces that the same variations must occur in M, although less discernible.

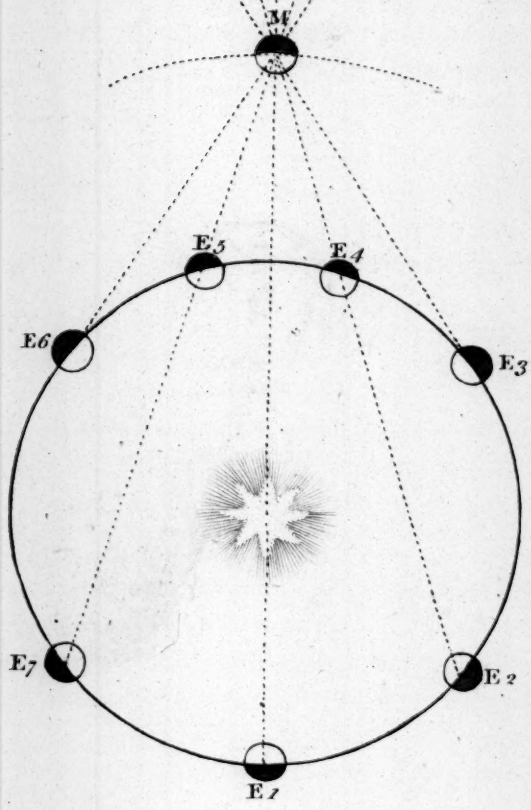
In tracing the course of V, we see she is at V 5, dark: at V 6 half light: at V 7, advancing towards full; further advanced at V 8; full at V 1; less light at V 2, and V 3; half light at V 4; and decreasing in light, till she reaches V 5; imitating in the course of her orbit the phases of the moon.

It is worth noticing the different places of a planet seen from the sun (*i. e.* its *heliocentric* place) and seen from the earth (*i. e.* its *geocentric* place): as at V 6, the first is S A; the latter E B. The heliocentric place of M 4 is B; its geocentric place nearly C; and so of others.

As



Courses of the Superior Planets.



As a proof of the truth of these principles, it remains to remark the apparent bulk of these objects, as seen from E 1: for it is evident, that V 1 is so very much further distant from E 1 than V 5 is, that she ought not to be of equal dimensions: and this is the fact; V 5 being largest of all, and the planet decreasing in magnitude as she approaches V 1, where she is smallest. This reasoning may also be inverted; if V 1 is so much smaller than V 5, her diminution proves she is further distant; if she is further distant, smaller, full enlightened, and also in conjunction with S, it demonstrates that her course is round S, and that it cannot possibly be round E, or round any other centre than S. The same reasoning applies to M.

This plate also hints at a similar appearance of the planet MARS (W). When the earth is at E 1, it sees W all across the system; a distance very remote indeed! consequently we may expect to find him small: but when the earth in her course arrives at E 2, W is by much larger and brighter. The foregoing reasoning applied to this article, proves that Mars circulates round S; and by consequence the other planets also.

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PLATE XI.

.....

COURSES OF THE SUPERIOR PLANETS.

THIS figure represents the appearances of the planet Mars (M), supposed to be at rest, while [E] the Earth performs one revolution. E 1, will see M among the firmament of stars at *a*; as E advances to E 2, M advances to *b*; and from E 3, appears at *c*; where he is stationary so long as the course of E is (as a little before E 3, and a little after E 6) nearly coincident with a straight line; but as E moves forward to E 4, M moves backward from *c* to *b*; between E 4 and E 5, M is seen in *a*, still going backward: at E 5 he is removed to *d*; at E 6 to *e*; from E 6 to E 7 he seems again to be direct in motion, advances to *d*; and from thence to *a* again. The extremes of the earth's orbit are the places where the planet M appears stationary; while E is in its furthest semicircle, M seems direct; when E is in its nearest semicircle, M seems retrograde. The courses of the other superior planets, partake of the same appearances: but on account of their distances and their apparently slow motions, they are not equally observable.

PLATE

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PLATE XII.

.....

SEASONS AND ROTATION OF THE EARTH.

THIS plate exhibits in the first place, the course of an equinoctial day. The earth's rotation being *from West to East*, in the order of the *figures* 1, 2, 3, 4, &c. That is to say, the line **11**. in one hour's time takes the place of that marked **12**, the line **10** takes the place of **11**, and so on: then **1** becomes **2**, **2** becomes **3**, **3** becomes **4**, &c. and all, in succession, will point at any stationary object situated above and beyond the rotation. Such an object therefore will, to the inhabitants of the globe, appear to advance in a *contrary* direction; as *a, b, c, d, &c.* according to the order of the *letters*. If we suppose a circular line like that which goes round the figure, to be elevated *over* this globe on the equator **E Q**, any fixed object in that line, would *seem* to advance in the order of the *letters*. We admit this object to be the sun.

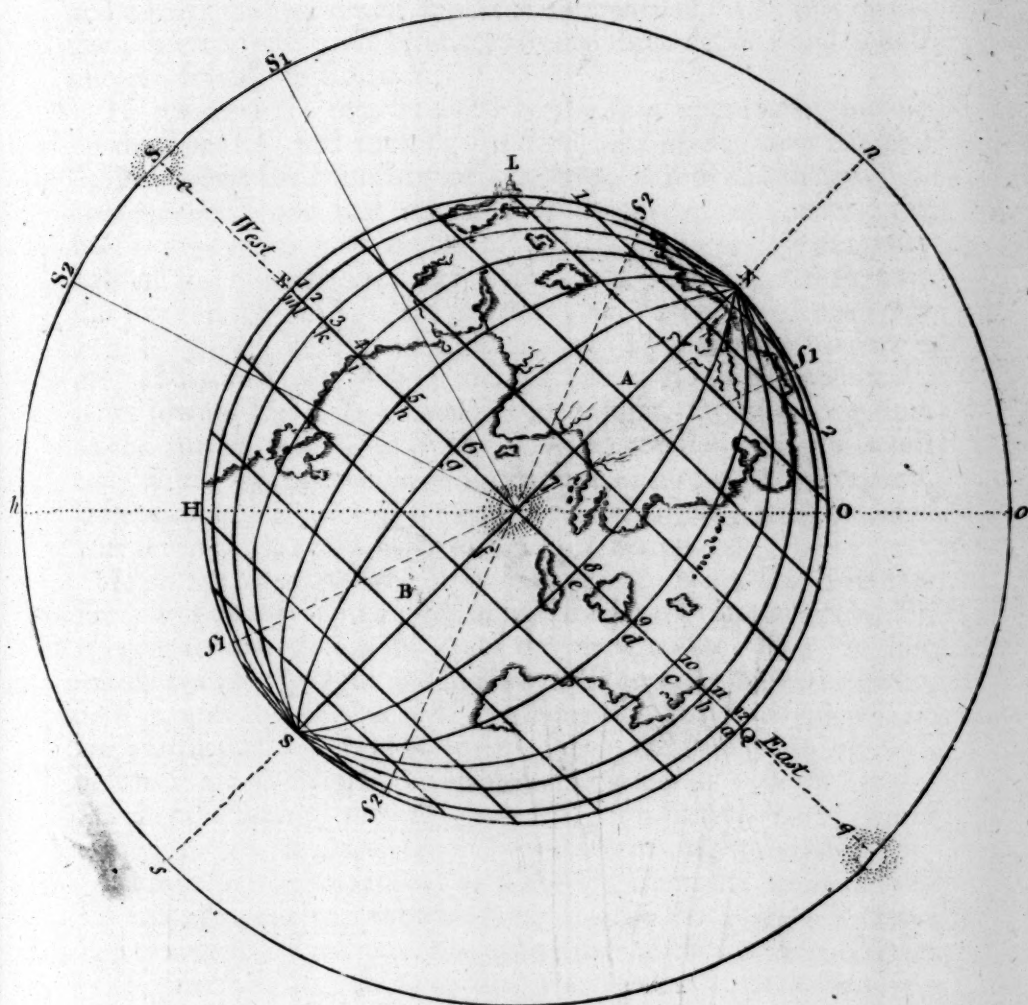
Wherever the sun is vertical it is noon. Suppose him vertical in the East, at **Q**; then it is forenoon to *a, b, c, d, e*; it is morning to *f*; and night to all beyond. As *f* gradually turns toward the Sun, till at length it points, *direct* to him, it is at *f* noon, it is forenoon to *g, h, i, k, l*, day-break to *m*, and night to all beyond: and it is afternoon to *e, d, c, b*, it is evening to *a*, and night to all beyond. As the earth continues her rotation, the sun *seems* to advance to *s*, where it is noon to **E**, afternoon to *m, l, k, i, h, g*, evening to *f*, and night to all beyond—Eastward.

The figure shews that when it is noon, evening, or night, to any spot under the line **E Q**, it is the same time of day to all places north or south of that line: As when the sun is on the mid-day (*meridian*) line, *7, f* it is not only noon to *7*, and to *f*, but also to **A** and to **B**; and it is equally day break to **H** to **E** and to **L**. The same principle applies to all other *meridians*.

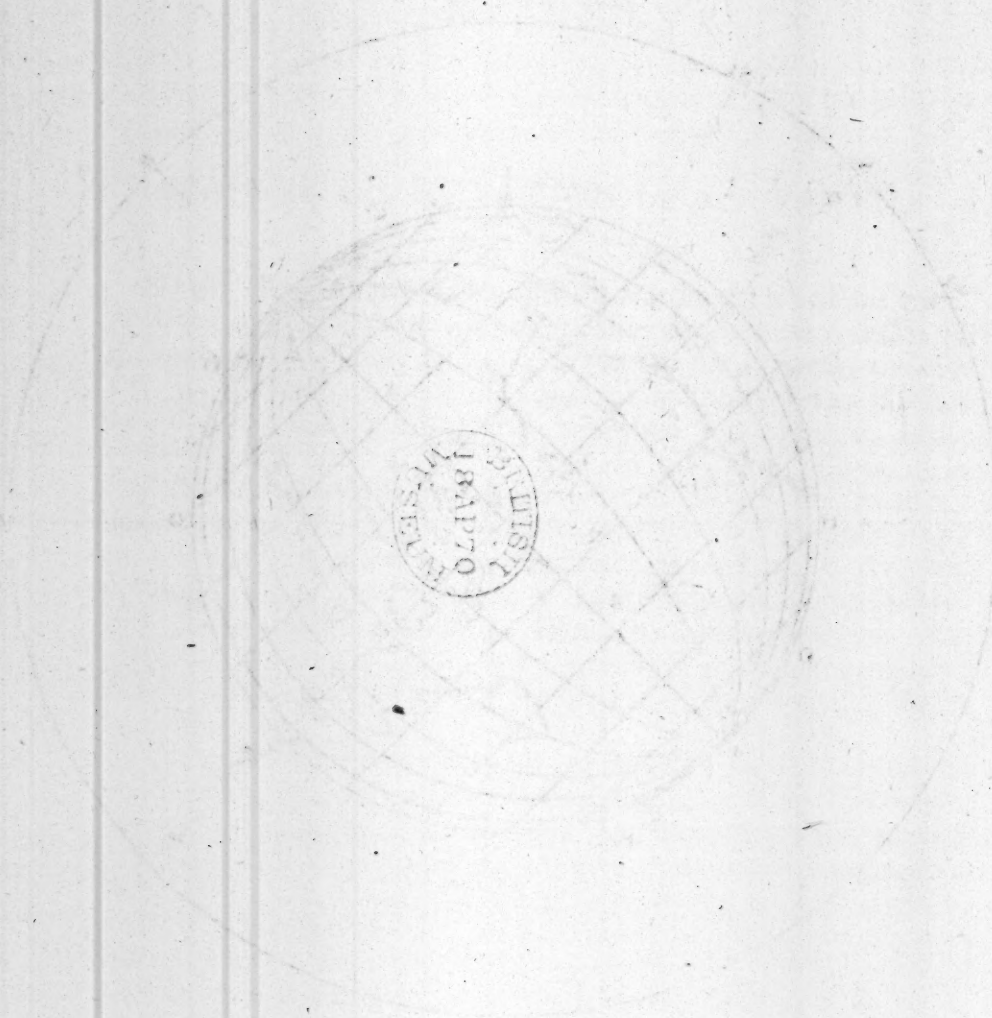
This figure also shews the different height of the Sun, at different times of the year; thereby producing the Seasons.

PLATE

SEASONS and ROTATION of the EARTH.



CLASSICAL and ROTATION OF THE EARTH



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If the poles of the Earth were *perpendicular* to the plane of the orbit in which she moves as a planet, there would be no variation of Seasons; but a perpetual Equinox would be maintained throughout the globe: whereas, the earth, being in fact, *inclined* to the plane of her orbit, no less than twenty three degrees and a half, this makes an apparent difference of *twice* that quantity; because we must estimate twenty three degrees and a half on *each* side of the Equator.

If we suppose, that S (*west*) be the sun, apparently moving on the Equator, and making *equal day and night*, then the line S, N. shews the boundary of his light; and of the shadow, in consequence: and that all parts of the globe, are, during the half of one rotation of the earth, in light; and during the other half of the rotation they are in darkness. But, if we suppose the sun raised from S (*west*) toward *n*, on the circular line, so far as to S 1, then the line which bounds the light and the shadow is S 1, above S on the globe; and S 1 below N. consequently all, parts toward N, as L. (London) enjoy light, during so long time as the surface from L to S 1 takes in its rotation—which is full two thirds of the whole time occupied in one daily rotation. The enlightened part is sixteen hours and a half, the shadowed part seven hours and a half, of the daily revolution.

If on the contrary, we suppose S to have *receded* from its station, and to have apparently moved toward *h*, on the circle, till it occupies the station S 2, on the circular line, then the line which bounds the light and shadow, will be *below* S, on the globe, at S 2, and above N at S 2. consequently, L (London) will be but a little while after it has emerged from the shadow on one side, before it enters the shadow on the other side; as appears by considering the figure: so that now the night is sixteen hours, thirty two minutes; the day is seven hours, twenty eight minutes.

Now these appearances, arise solely, from the inclination of the axis of the earth: which at one time of the year as it circulates round the sun exposes a greater part of the southern surface of the earth to the action of the solar beams: and at the opposite time of the year exposes its northern surface to the same effects, in the same manner and proportion.

PLATE XIII.

VIEWS OF JUPITER.

THESE figures shew the appearances on the body of this planet seen through a telescope, and called his belts. Sometimes they seem as if united into breadth: sometimes transverse spots seem to form a communication between belt and belt; sometimes they seem more distinct, and in lines, and shew bright spots; and sometimes, but rarely, they seem almost dissipated. Whether they are extremely dense clouds, and the bright spots, are mountain tops seen above them; or whether they are waters impelled very fiercely by the rapid motion of the planet's rotation, or attracted into tides by his moons, may be rather conjectured than determined. They are thought by some to be variations of his atmosphere.

PLAN OF JUPITER'S SYSTEM OF MOONS.

THESE are drawn according to their distances from the planet; and are marked as they are usually denominated, beginning with that nearest to the planet.

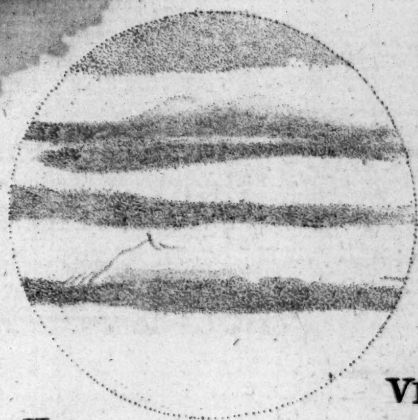
PLATE XIV.

ECLIPSES OF JUPITER'S MOONS, AND VELOCITY OF LIGHT.

IN this figure S is the sun, E 1, E 2, E 3, E 4, is the orbit of the earth, AB part of the orbit of Jupiter, a Jupiter's first satellite supposed to be seen casting a shadow ($b c d$) on its primary, $f g$ the same satelite supposed to be eclipsed by its primary.

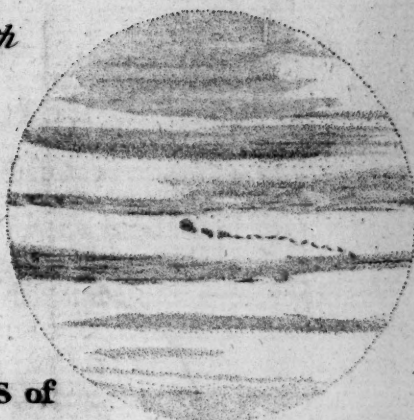
We observe, that a , seen from E 1, seems to follow its shadow ($b c d$) falling on Jupiter, being eastward of it, so that it seems just to touch the disk of the planet when its shadow is at least passed half way over it; and before the satelite appears to be advanced to the middle of Jupiter, the shadow will be gone off at d : but if a be seen from E 3, it will appear to go before its shadow, and will be passing off the disk of its primary at d , while its shadow yet appears at c .

On



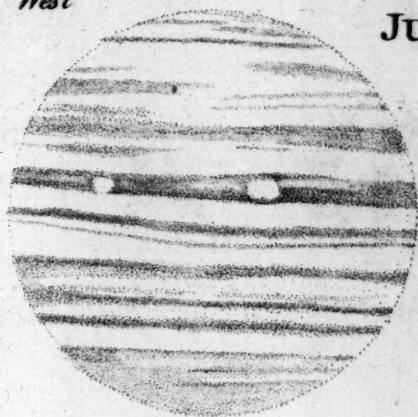
West

North

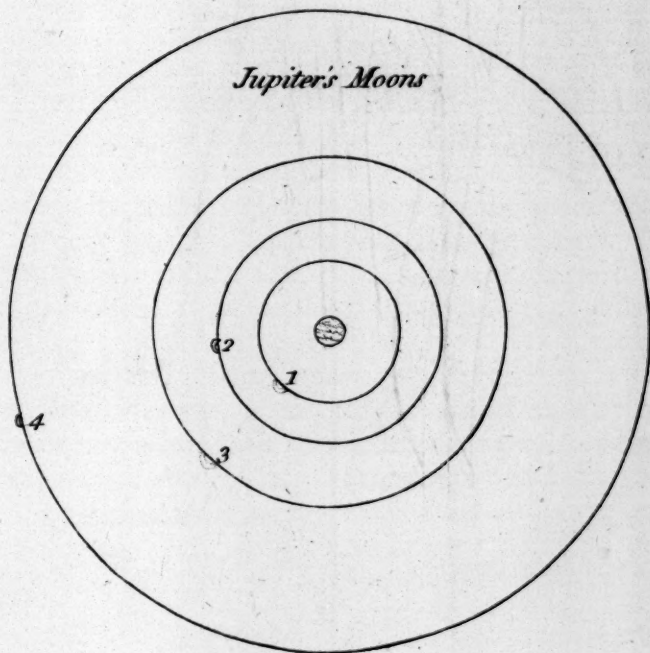
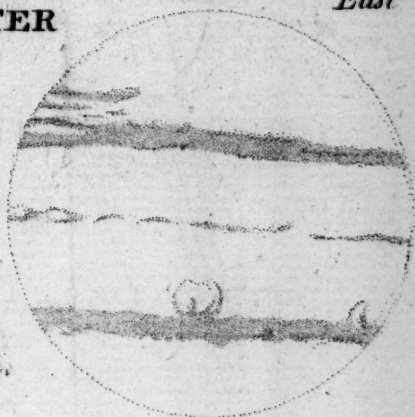


**VIEWS of
JUPITER**

East

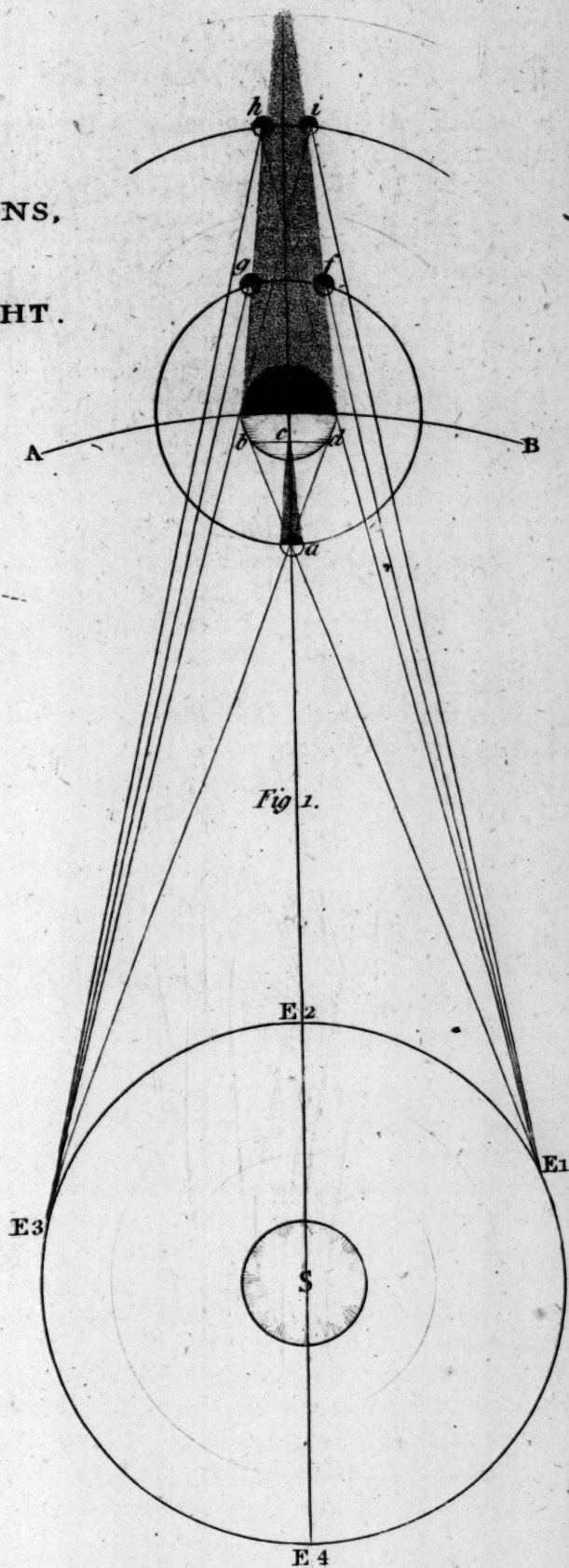


South





ECLIPSES of
JUPITERS MOONS,
and
VELOCITY of LIGHT.



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On a similar principle the immersion of *f* into the shadow of Jupiter, is discerned from E 1; but its emersion or exit from the shadow, cannot be seen, being concealed by the body of the planet: whereas at E 3, its emersion only is visible, and its entrance into the shadow is hidden. This is regularly the case of the first satellite, and generally also of the second; but the third shews frequently both its immersion and emersion, as *i b*, the entrance *i* is visible, both from E 1 and from E 3: as also is the exit *b*. As to the fourth satellite, it is so far from Jupiter, that Jupiter's shadow is much diminished ere it reaches it; by which, together with the inclination of its orbit to that of its primary, it seldom is eclipsed, but passes above the shadow; or sometimes, it suffers a partial eclipse, as in fig. 2, in which remarkable situation it was seen by CASSINI the astronomer.

It is proper to observe, that the appearances of the satellites vary, sometimes passing over the body of Jupiter as dark spots, sometimes bright like himself, and not to be distinguished from him; this renders it probable that these satellites have a rotation, each on his proper axis, whereby sometimes that part of a satellite which is least fitted to reflect light (spotted perhaps with land and water) is turned towards us, at other times we see that side *most* fitted to reflect light. This also varies the brightness of these moons: the fourth which is generally the least, is sometimes the largest of all; the third, which is usually largest, is sometimes least; and so of the others.

The size of the satellites is about half a diameter of the earth; the third rather larger. CASSINI suspected the first satellite to have an atmosphere; because the shadow of it could not be seen, when he was sure it should have been on the disk of Jupiter, if it had not been shortened (like the shadow of our earth) by an atmosphere.

We are beholden to these satellites, for the first proof that the passage of light is not *instantaneous*; but, though extremely rapid, yet that it takes *some* time in passing from one place to another: thus, while E 4 is advancing towards E 1 (nearer to Jupiter), the immersions more and more *anticipate* their true times, as calculated by their just theory; whereas while E 3 is going to E 4, the emersions appear later and later. The distance is still greater between E 4 and E 2, and makes a difference of sixteen minutes *later*, to E 4; *sooner* to E 2. How is this variation to be accounted for? or what consumes sixteen minutes of time? The motions of these bodies are doubtless exactly regular: but, in fact, the difference of the diameter of the earth's orbit occasions this variation; in traversing which, the light consumes so many minutes. The first ray from an emerging satellite, is

like a messenger sent to relate the news ; if we advance to meet him, we by so much anticipate the time of his telling his tale ; but if we retire further from the place whence he is dispatched, he must needs take additional time to follow us.

The principle to be drawn from this fact, is, that as we see the heavenly bodies only by their light, and that light has taken some time in its passage to us ; so during that time the luminary has continued its progress, and is not *now* in the very identical spot it occupied when its light was emitted, and sent to our eyes. Thus the sun is perhaps seven or eight minutes farther advanced in his daily course than we see him to be, and a fixed star dispatched toward us those rays by which we now see it, perhaps not only months, but years ago ; which time is consumed in the passage of its rays through an interval so astonishing.

The principle adopted for finding the longitude, by means of the satellites of Jupiter, is, by tables calculated for any fixed meridian (as that of London) shewing their exact station at any certain hour of the day (as nine o'clock in the evening). By observing, in Jamaica, for instance, the precise time when the satellites present the same position to a spectator there, the difference of TIME between that place and London is found ; which is easily turned into degrees, and minutes, allowing, 15° to the hour.

.....

PLATE XV.

APPEARANCES OF SATURN DURING HIS COURSE.

THE peculiarities of this planet's appearance, arise chiefly from the changing form of his RING ; which, although it does not vary in itself, but always maintains the same local station, yet presents to our inspection a regular mutation and diversity. In this view the smaller letters *a, b, c, d, &c.* presents the planet and his ring, supposed to be seen by a spectator at a proper distance, during one revolution. The larger letters *A B C D, &c.* shew the figure of the planet and ring seen from the earth, at corresponding periods. The orbit of the earth is so small in proportion, that the same appearances, very nearly present themselves to a spectator in the sun.

We observe, that when Saturn is in his ascending node at *a* the edge of the ring (which is conjectured to be eight hundred miles thick) being turned toward us, we see nothing but a shade on the body of the planet, as at *A* ; at *b* the ring becomes visible, and in this form is (very improperly) termed *Ansa* (handles) because

Appearances of Saturn

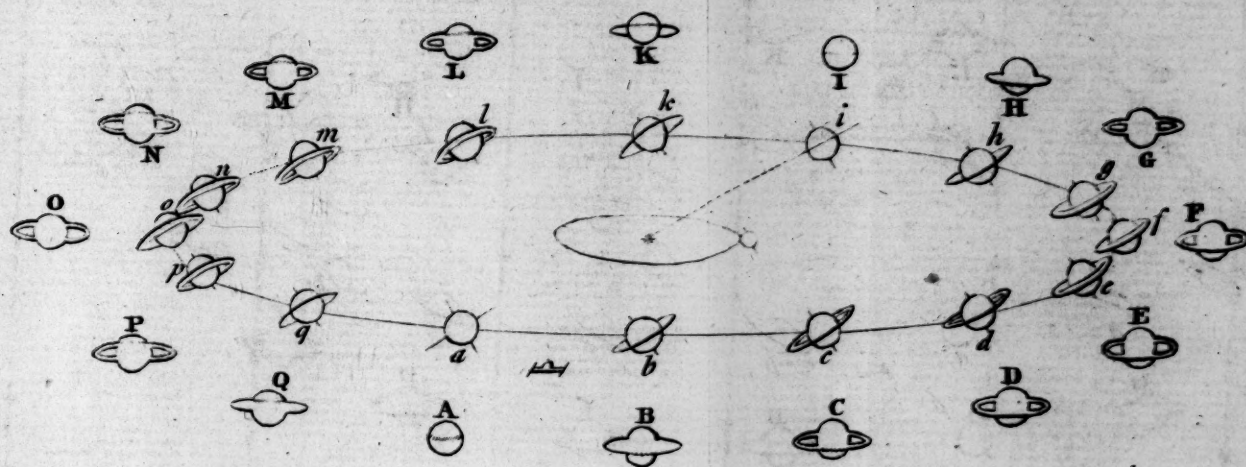
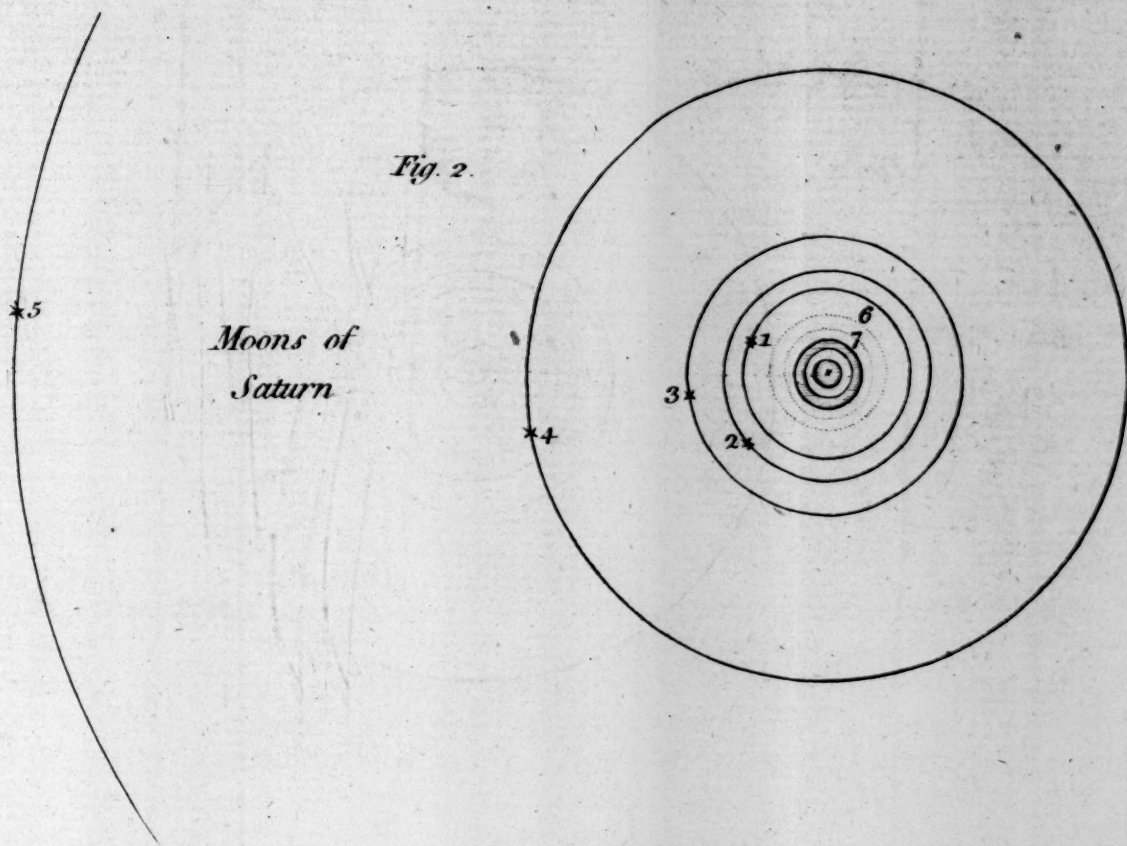


Fig. 2.

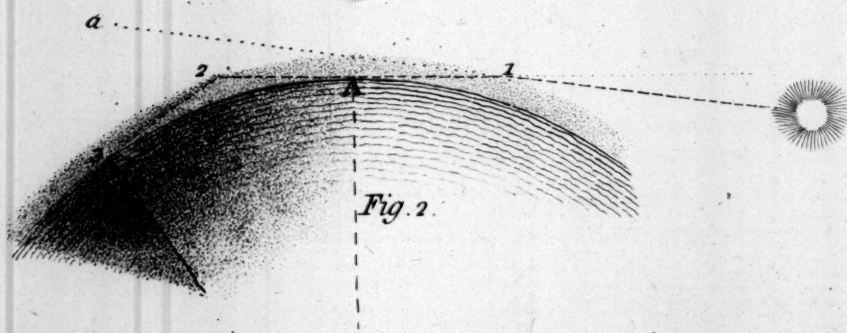
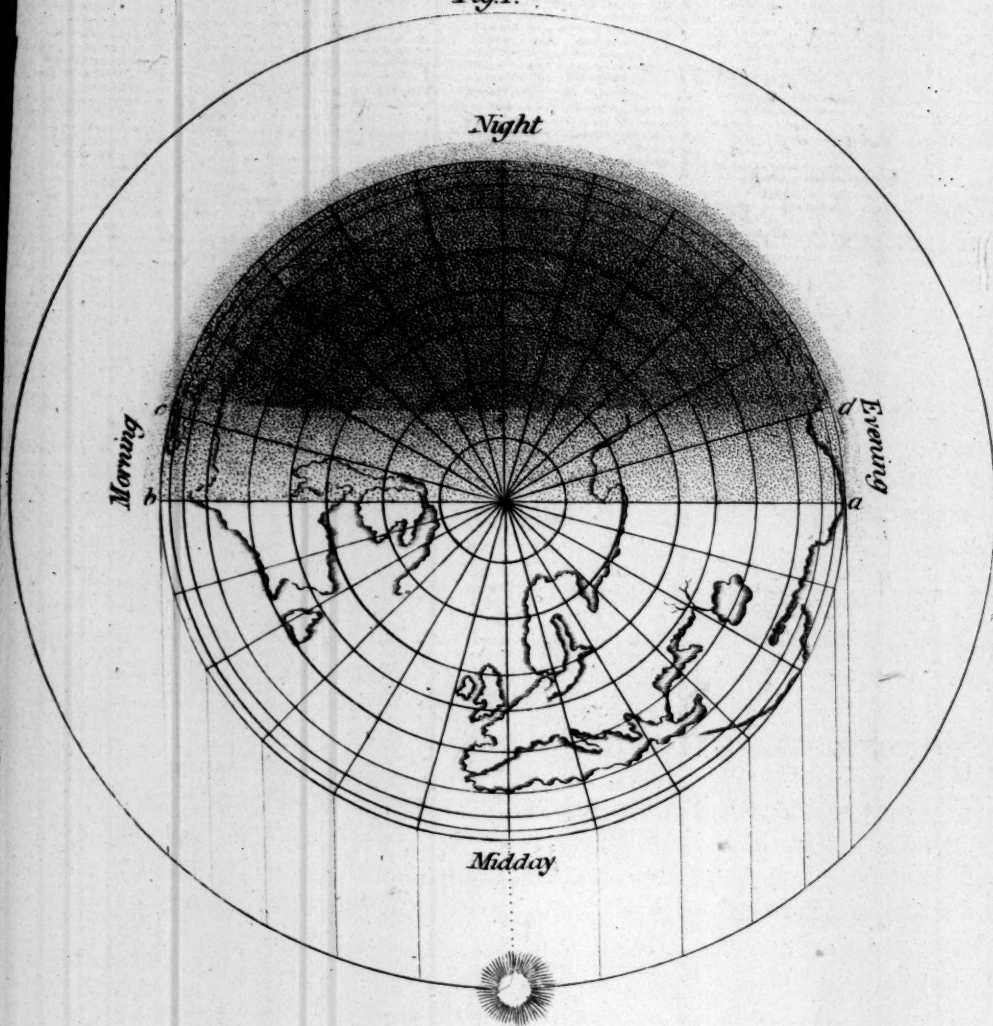
Moons of Saturn





TWILIGHT.

Fig. 1.



because it happened to be seen in this situation through the first telescope of GALILEO, who being ignorant of its progressive variation, likened it to what it is now found to be totally unlike. At *c*, the ring opens, and continues to widen till it reaches *e*, from whence it as gradually declines through *f*, *g*, *h*, to *i*, where having fulfilled half a revolution, and being again in its node (now descending), it is not seen. It is clear, that hitherto the *upper* (or *northern*) surface of the ring is what has been seen by us, as also by the sun; consequently the solar light has hitherto visited only that surface: but from *i*, during the remainder of the course, the *under* (or *southern*) part of the ring becomes visible, and continues exclusively to enjoy the rays of the sun. The progressive increase of the ring to *n*, and its subsequent decrease, being the exact counterpart of the former semi-revolution, needs no comment. Dr. CLARKE's father once saw a fixed star through the interval between the ring and the planet.

FIG. 2. PLAN OF SATURN'S SYSTEM OF MOONS.

These are delineated according to their distances, we know little concerning them, besides the periods of their revolutions.

The orbits of the satellites coincide with the plane of the ring (*i. e.* about 31° from that of the primary), except the fifth, whose orbit inclines only $13^{\circ} 8'$. The orbit of the fourth is eccentric.

PLATE XVI.

FIG. 1. represents a general idea of the benefits resulting to the earth by the intervention of an ATMOSPHERE. This is supposed to be the northern hemisphere; the north pole being in the centre of the figure; and the Sun being in the equator: consequently, this offers the aspect of the globe, at the time of the *Equinox*.

It appears by the figure, that those parts which have lately, by the diurnal rotation of the earth, been turned from the sun, and are losing sight of him (*i. e.* the part marked *Evening*), yet continue to enjoy his beams, by the refraction of the atmosphere: were no such medium interposed around it, *a* would be involved in night: whereas, night is but just sensible at *d*, and the interval between those letters, is gradually preparing for the total absence of the luminary. At *Mid-day* or *Noon* the atmosphere spreads

spreads the rays of light all around, and diffuses equal and general brightness. In *Morning*, as the parts of the globe, *b* and *c*, are turned toward the sun, the light gradually brightens, so that, although in strictness only *b* *should be* illuminated, yet the atmosphere extends the solar rays to *c*, and gradually prepares those parts for perfect day.

Thus it appears, that though the central line *a b*, *should be* the natural boundary of day and night, yet by this invaluable contrivance, a considerable surface beyond that line is rescued from darkness, and the actual boundary of light and shade is removed to *c. d.* In fact, therefore, the pole has now no night; though all other parts of the globe have equal day and night.

It is supposed in this figure, that the rays of the sun fall *parallel* on the earth: this we have already observed is not the fact, but they illuminate more than half the globe *constantly*; by which superiority of illumination, especially when aided by the atmosphere, the extent and duration of darkness is very much lessened, and light is proportionately increased, for the purposes and enjoyments of life.

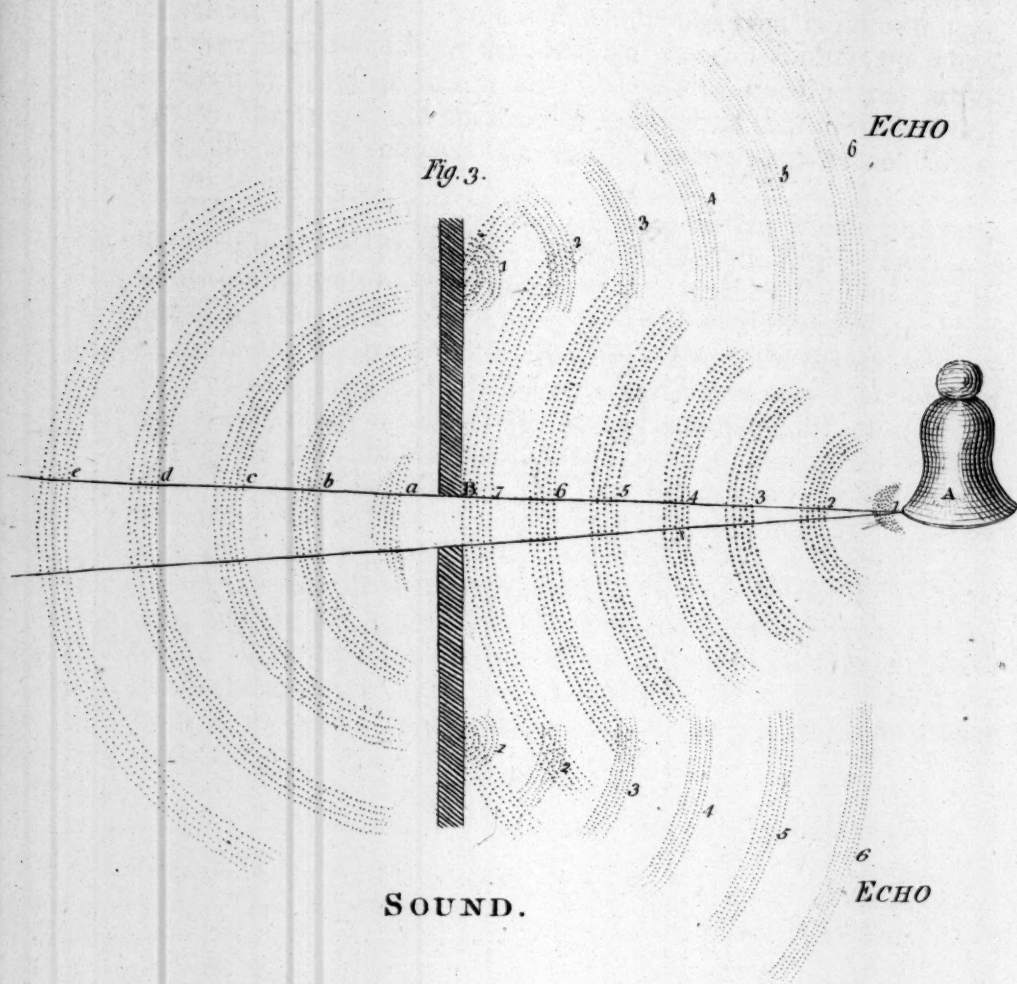
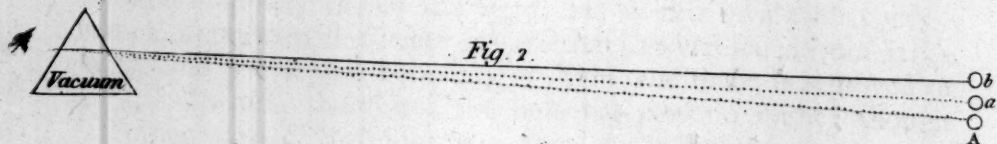
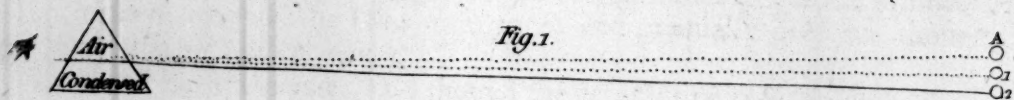
This figure is a kind of companion to the last which explained the rotation of the earth: the circle in which the sun is *supposed* to move in this figure, corresponds to that marked *E Q* in that figure, and the effect of the sun, is what would take place when he is in the station *f 7* of that plate. From the combination of these figures, seen in such different aspects, a very clear idea of the diurnal rotation and its effects may be obtained.

Fig. 2. Is a more distinct view of twilight than could be given above: we observe, that the ray from the sun to *1*, which would naturally proceed direct to *a*, is by the atmosphere at *1*, caught and inflected to *2*, just striking *A* in its passage; and thereby rendering the sun visible to *A*, although that orb be below his horizon, which is *1, 2*. This ray is again deflected from *2* to *3*, where night begins; the sun being full eighteen degrees below the horizon of any spectator supposed to be at *3*. The space from *A* to *3* is gradually darkened, 'till at *3* it becomes totally void of light.

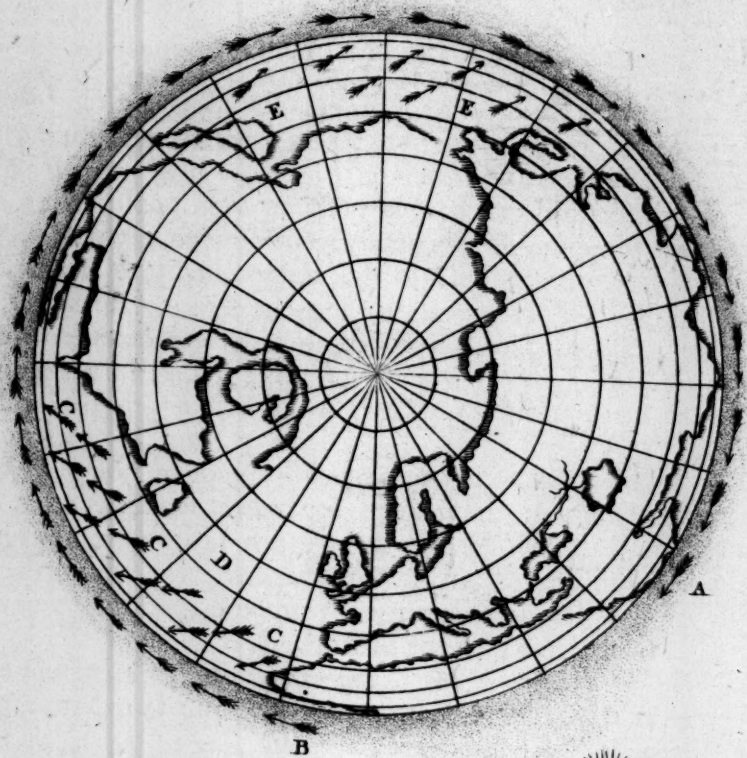
ATMOSPHERIC



ATMOSPHERE.







WINDS.

PLATE XVII.

FIG. 1. and 2. Refer to experiments for ascertaining the refractive powers of the ATMOSPHERE, Performed by Mr. Hawkbee, before the Royal Society.

Fig. 1. The prism is charged with an additional portion of air, rendering the quantity it contains *double* what it would be in a natural and free atmosphere: in this compressed state of the air in the prism, the object appears to the eye looking through the prism to be at A; as the compressed air is let out of the prism, the object descends to what would be its true station in open air; *i. e.* from A to 1 and 2: which is a descent of ten feet and a quarter.

Fig. 2. The air naturally contained in the prism being gradually extracted from it, the object apparently descends from its true station in open air (*b*) to *a* and A (ten feet and a quarter). Upon the re-admission of air into the *vacuum*, the object apparently rises from A, to *a* and *b*; merely by the refractive powers of the air so re-admitted into the prism.

SOUND. Fig. 3. This figure endeavours to represent the waves of agitated air, in the action of conveying sound from the vibrating body A. At first they are strong, as 1, 2, 3, 4, but they weaken as they recede from A to B; whose interposition prevents their progress, except at the orifice B, through which they proceed, as it were, afresh, in *a, b, c, d, e*; weakening as they go, till they become insensible (*i. e.* the sound becomes *in-audible*). Those rays which are stopped by the wall B, return, and form an ECHO, which weakens correspondently to its distance from the reflecting body, as 1, 2, 3, 4, 5, 6, till at length they become totally quiescent.

According to the situation of an auditor, he will hear the original sound, and the echo, more or less *separate*; at echo 1, they will be almost union, but at echo 6, there will be a considerable interval between them.

PLATE XVIII.

WINDS.

IF the whole superficies of the globe were ocean, and, in consequence, free from impediment, it is probable, the surrounding atmosphere would be so uniformly moved by the solar influence, that only one wind (and that following the course of the sun) would ever prevail throughout the globe.

Where

Where the sun is vertical it is noon, and here the figure represents a very considerable expansion of the aerial fluid, occasioned by the heat of the sun, which, as the globe turns B toward the sun, *pushes forward* those parts of the atmosphere toward which the sun is advancing, the heat increasing upon them continually, till the sun becomes vertical, while the parts A turning from the sun, become gradually cooler by his absence, and the air rushes forward to supply the progressive vacuity which follows the expansion. This scheme would represent the natural effects, were the superficies of the globe *smooth, e. gr.* being water: but as it really is, the prominences of the land check and divert the courses of the winds, so that they are permanent only on such wide extended oceans as are beyond the influence of the land's attraction, as at C C C, and E E.

We observe also, that the direction of the arrows CCC, [which shews the course of the wind] is not the same as those A and B; but it gradually becomes conformable to it, while at the distance D, the air feels little or nothing of these motions, being liable to variableness, and changes, from a variety of local and temporary causes.

N. B. The greatest expansion of the air is not *actually* under where the sun is vertical, but is somewhat advanced into the afternoon, and may be considered as being at A, the heat increasing for some time after the sun has ceased to be vertical.

The lower figure is a view of the globe, shewing the courses of the winds on each side of the equator E Q. A B is part of the great South Sea, the wind blowing steadily, in a course combined of north and east, toward the equator: but by the intervention of the lands, islands, &c. between C and D, the wind is attracted out of its course, and changes very considerably from it. Passing these parts, we observe that from E to F the wind blows steadily again in an inclination toward the equator; but it is from parts where there is no land, which being to the southward, its direction is now a combination of south and east, and in this course it blows till it is contradicted by the vicinity of land; which alters its direction, as at I. G shews that half the year the wind blows one way; H shews, that the other half of the year it blows directly contrary in the same parts. This takes place where the sea may be said to be bounded by projections of land; but it is unknown where the ocean is widely expanded. The southern as well as the northern parts of the globe sustaining less heat, exhibit no such regular or periodical winds, but their cooler atmospheres are more influenced by local, and particular, causes and circumstances.

18 AP 79

INDEX.

INDEX OF PLATES

TO

NATURAL PHILOSOPHY.

Air to face page	33	Refraction to face page	105
Water	43	Prismatic Colours	107
Earth	61	Rainbow three circles	108
Fire	68	Rainbow two rows	110
Springs	102	The Eye	154
Tides	104	The Ear	155

.

PLATES TO

ASTRONOMY.

Plate 1.	Solar spots to face page	—	—	201
2. 3.	Views of the moon between pages	—	202	203
4.	Phases of the moon page	—	—	203
5.	Orbit of the Moon and Eclipses	—	—	204
6.	Parallax and Eclipses	—	—	206
7.	Eclipses	—	—	208
8.	Characters of the Signs	—	—	209
8.	Solar System	—	—	211
10.	Courses of the inferior planets	—	—	213
11.	Courses of the superior planets	—	—	215
12.	Seasons and Rotation of the Earth	—	—	216
13.	Views of Jupiter	—	—	218
14.	Eclipses of Jupiter's Moons, &c.	—	—	218
15.	Appearances of Saturn during his Course	—	—	220
16.	Atmosphere	—	—	221
17.	Atmosphere	—	—	223
18.	Winds	—	—	223

.

The PLATES to the DRAWING PRECEPTOR, are to be placed after page 22, in their order from 1 to 19.

.

The PLATES of ARCHITECTURE, after page 32, in their order.

INDEX OF PLATES

TO THE

BOTANICAL PRECEPTOR.

FRONTISPIECE. A figure of Botany examining and delineating curious exotics: for the purpose of arranging them under their respective *Genera* and *Classes*.

Plate 1.	Roots to face page	_____	27
2.	Trunks	_____	28
3. 4.	Simple leaves between pages	_____	30 31
5. 6.	Compound leaves pages	_____	34 35
7.	Supports to face page	_____	38
8.	Foliation to face page	_____	89
9.	Calyx to face page	_____	90
10.	Corolla	_____	91
11.	Pericarpium	_____	92
12.	Receptacle	_____	93
O. P.	Linnean system between pages	_____	94 95
Q.	Linnean system to face page	_____	95
R.	Linnean system	_____	96

The Binder is desired not to pull the Book to pieces, as he has secured the Indexes of the plates, &c. which are placed as follows: Index of Plates to Geography, a leaf in No. 12. also, on this half sheet.

18 AP 70

Chronology, Frontispiece only.

Index of Plates to Natural History—Beasts—Birds—and Fishes, a half sheet in No. 26. N. B. The Diver *omitted* place to face page 299—Index to Insects page 76—also a quarter of a sheet in the last No. to be added to this division including the plates of Blue Bottle Fly—Eyes of a Fly—Cheese Mite—Feather-winged Moth—Mouldiness—and Stinging Nettle.

Index to Natural Philosophy—Index to the Senses—Index to Astronomy—Index to Drawing and Architecture on this half sheet.

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FINIS.